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Illuminating Urban Agriculture: a new framework for understanding complexity

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a new framework for understanding complexity

Master's Project

by Helena K. Farrell

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DEDICATION

This work is dedicated to present and future trailblazers seeking socially vibrant, economically viable, and ecologically sound human ecologies.

Abstract

Modern, conventional food systems vulnerable to declining fossil fuel resources are a 21st century plight demanding rapid transition to regenerative agricultural practices. Urban agriculture is currently responding; expanding and diversifying from recent and historic roots worldwide to help meet the needs of contemporary urban dwellers and ameliorate the aftereffects of industrial agriculture.

Urban Agriculture is comprised of many different styles, practices, and modes of production. From traditional to state-of-the-art, they result in a range of landscape typologies occurring around the globe. The tremendous variety creates the need for better articulation and more accurate distinctions between actual urban farm systems. In order to understand their respective advantages and disadvantages, and the differences and similarities of disparate modes of production, a comprehensive method is needed that allows for comparative analysis and assessment.

The evaluative framework developed for this research is a tool for evaluating urban farm systems with a current and comprehensive set of criteria and metrics. It can be used to inform and inspire urban planners, designers, policymakers and community members seeking to maximize the potential of existing projects or successfully customize urban agriculture in new locations.

While the long term role and significance of urban food production in feeding the global population is unclear, understanding its myriad benefits and positive impacts locally and globally is imperative.

Introduction

BACKGROUND AND CONTEXT OF RESEARCH

As long as there have been cities, there has been urban agriculture. Practices are currently expanding both from historical deep roots and on brand new fronts. According to the United Nations Development Programme, urban agriculture is now meeting significant amounts of food needs in cities worldwide, such as Havana, Accra, and Dar-es-Salaam which have been studied extensively (Girardet, 2005).

While its high-density typology and existing infrastructure efficiently meets the demands for housing, transportation and services, the urban habitat often lacks adequate the capacity to grow food. With agriculture largely removed from contemporary urban centers, cities rely on an increasingly globalized food supply that is largely out of their control. New research and design are exploring how cities retrofitted to facilitate with urban agriculture may offer more sustainable human habitat and make cities more ecologically sound; adding to its well-documented advantages in improving quality of life, food security, nutrition and local economic development in cities.

The many different modes of urban food production generate interesting landscape typologies that have the ability to serve multiple functions in urban open space and appeal to contemporary architects, landscape architects, planners and community leaders. Urban agriculture's diversity, malleability and multiple benefits are appealing as sustainable solutions to social, environmental and economic ailments. As this previously marginalized subject enters the mainstream, planners, designers and practitioners must equip themselves with the knowledge of its complex nature, diverse manifestations and the interwoven human, ecological, and economic relationships that necessarily create and sustain it, as well as with the means to evaluate the various alternatives in terms of their adaptability and appropriateness to specific contexts.

While urban agriculture is in part, a direct response to the declining viability and integrity of industrial

Pueblo Grifo Nuevo, Cienfuegos, Havana, Cuba
Source: Diaz & Harris in *CPULs,* Viljoen, 2005

West Cottage Street food lot in Dorchester, MA
Source: *Urban Grower's Manual,* The Food Project, 2008

Urban food system typology within the urban fabric
Source: *Food Urbanism:* a sustainable design option for urban communities, Grimm, Jason, et al., 2009

agriculture, it is not an attempt to return to pre-industrial ways of life. Rather, it is seen as having the potential to serve as critical infrastructure for surviving (or preventing) times of resource scarcity and catastrophic changes to the natural and engineered systems within which we currently live. Urban agriculture both ameliorates negative conditions and establishes the groundwork for positive transition in the way we inhabit the earth. Embarking on this process is long overdue and appropriately answers the appeals for change being made in formal and informal discourse around the world.

This research explores urban agriculture as a means for social, economic and ecological development, as well as a vital component of the food system supporting cities. A custom research method has been created to appreciate its diverse, extraordinary benefits within a comprehensive framework. The stance behind the research is not that urban agriculture could or should aim to meet 100% of food needs, but that it is perfectly poised as a key component of the food system, capable of providing multiple social, ecological and economic benefits, reducing the ecological footprint of cities and making them more livable. Also, urban agriculture is often well suited to embody and demonstrate regenerative agricultural practices as a way of addressing the environmental consequences, declining productivity and vulnerability of conventional agriculture. Beyond the scope of this study, regenerative urban agricultural practices can offer a model for sustainably transforming other modern, globalized urban systems and practices facing similar crises.

PURPOSE

The importance of food as a fundamental and vulnerable resource has given urban agriculture a place in the discourse of sustainability and made it an emerging subject of contemporary urban planning and design. The purpose of this project is to address the need for a new evaluative framework and research methodology, including value metrics and assessment criteria appropriate for urban agriculture in the present day. An updated set of tools calibrated to measure factors of present day relevance is needed for assessing the productivity, benefits and impacts of urban agriculture in the modern context. These more complete and accurate assessments are needed to cultivate an overarching understanding of urban agriculture as an important vehicle for beneficial change in 21st century human ecology and to offer a range of realistic strategies for successfully implementing new projects.

SCOPE OF RESEARCH
Questions

This research will investigate:

- What are major, leading examples of urban agriculture?

- What are their corresponding ecological services, economic models and social structures?

- What are the essential functions and benefits that can be compared?

- What criteria can be used to evaluate their performance?

- Can the need for greater labor and expertise in managing urban agriculture projects be compensated for by qualitatively greater productivity or by a wider range of benefits?

- How is food security defined and how can urban food production contribute to it?

- How is a viable local economy defined and how does urban food production contribute to it?

- What are the emerging opportunities and strongest potential for implementation of sustainable urban agriculture?

GOALS AND OBJECTIVES

The goal of this project is to develop a new, comprehensive analysis and assessment model for urban agriculture and to demonstrate it by producing 3 or more flexible frameworks of designed urban agriculture systems capable of customized reproduction to support the process of creating viable, equitable, regenerative food systems in urban communities around the world. This goal will be met through these objectives:

- Analyze the designed systems of 2-3 different modes of urban agriculture with regard to form and function.

- Identify and develop appropriate value metrics and assessment criteria for evaluating each system's benefits and productivity.

- Develop a comparative analysis and assessment model to reveal strengths and weaknesses, opportunities and challenges of the different modes.

- Understand and illustrate the interrelationships between land, economy and community that yield different types of successful regenerative food production.

LIMITATIONS AND DELIMITATIONS

This research will respond to the identified gap in empirical knowledge on urban farm system design and the need for new agricultural metrics and assessment criteria of contemporary relevance. Inventory of the state of the art has revealed substantial information on the social benefits and, to a lesser degree, economic and ecological benefits of urban agriculture. Challenges and constraints to particular projects have also been investigated by previous research identifying best practices and policy strategies. The existing body of knowledge both delimits and reinforces this project, whereby a focus on design within a social - ecological - economic framework will make a new and valuable contribution to the field. By creating an evaluation tool and demonstrating an analysis and assessment method, this project will help differentiate, multiply and verify some of the divergent practices that constitute urban agriculture.

Also, while it may be possible to identify best practices or essential guidelines for success, a tremendous range of applications of urban agriculture will remain. The variety of particular cases and the richness of information they contain create the need for a comprehensive and exacting critique, more accurate distinctions and better articulation of farm systems within research and practice. The comparative analysis and assessment method will be a practical tool for producing this useful overview of urban agriculture. In addition, it can support research into evolving modes of production, guiding the redesign of existing farm systems and offering strategies for new projects.

"…a full conceptual system that presents a structure of interconnecting compartments anchored into real-world experience…

…a conceptual yardstick for identifying meaningful differences & gradations to support urban agriculture policy and technology."

-Mougeot, Luc J.A

Source: *Urban Agriculture: Definition, Presence, Potentials and Risks,* Thematic Paper 1

Literature Review

MODERN CONVENTIONAL AGRICULTURE

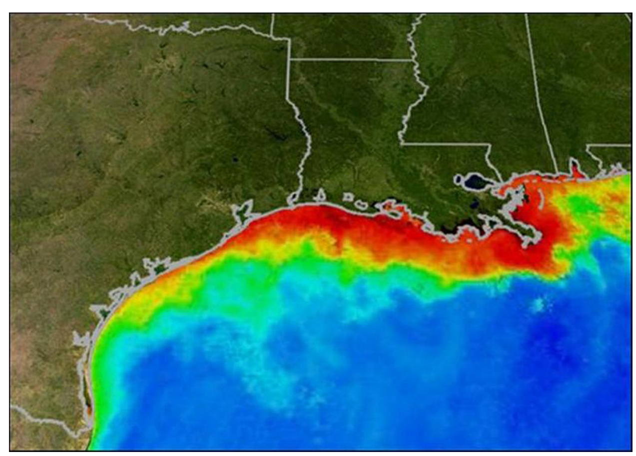
Since its origin when people first planted and harvested crops instead of foraging for food in the wild, agriculture has been subject to the mutual logic of humans and nature. It is a system that integrates social and biological processes. For humans, the goal has been to grow food abundantly and affordably.

Over the millennia, modes of agriculture have diversified and adapted to meet this goal. Most recently, in the 20th century, industrialized forms of agriculture have made the greatest advances with systems and technologies that have increased yields exponentially and minimized costs through economies of scale, reduced system complexity, and perhaps most significantly, reliance on cheap, nonrenewable fuel. Modern, industrial agriculture consists of farming systems characterized by monocropping and mechanization at massive scale serving a global food system that provisions diets around the world. Within the past century, annual agricultural production has more than tripled, largely due to the advent of chemical fertilizers, pesticides, herbicides, and powered farm machinery. The application of fossil fuels to the food system enabled human population to grow from less than two billion at the turn of the twentieth century to nearly seven billion today (Heinberg, et al, 2009).

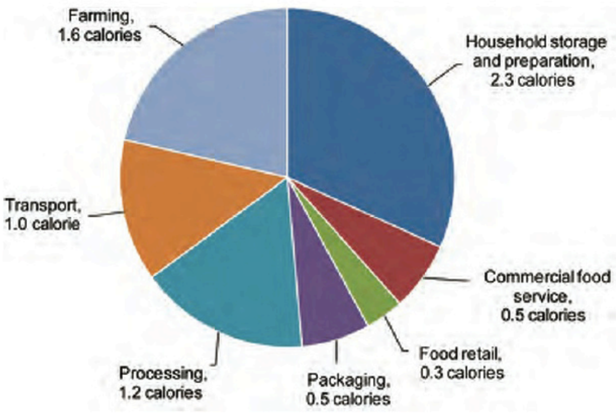
Expanding rapidly between 1920 and 1990, industrial agriculture quickly dominated other farming systems. It has transformed the nature of production, manufacturing and consumption within the entire food system (Gottlieb, 2001). On the one hand, the profit-driven, commercial food system that we know today has been exceedingly good at meeting the goal of producing food abundantly and affordably. On the other hand, it has had devastating social and environmental effects worldwide that are unaccounted for by conventional economic formulas. As a result, contemporary humanity faces the dilemma of being dependent on a food system with vital flaws that threaten the future of life on earth (Heinberg, et al, 2009).

Crop duster sprays pesticides on a monocrop
Source: wikipedia

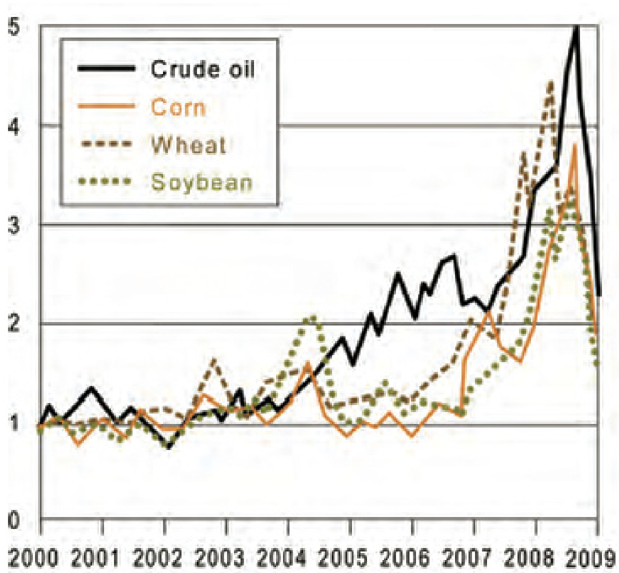
Runoff contaminated with agricultural fertilizers
Source: wikipedia



Dead zone in the Gulf of Mexico
Source: wikipedia, NASA, NOAA



Energy expended to produce and deliver one food calorie
Source: Heinberg, et al. 2009



Relative price of crude oil, corn, wheat, and soybean on world markets, 2000-2008
Source: Heinberg, et al. 2009

Environmental consequences

The wide spread adoption of market-driven, industrialized agriculture has had major, continuing environmental consequences. In fact, it has been the source of greatest human impact on the environment yielding disastrous effects on the biosphere and atmosphere that threaten the future of life on the planet. Fertilizer runoff proliferates oceanic dead zones, the search for arable land drives deforestation, soils are salinized by irrigation, air and water are polluted by pesticide and herbicide, and biodiversity is compromised by the simplification of ecosystems in the production of monocrops. Agriculture also contributes to climate change, both through soil degradation and the combustion of fossil fuels, which release carbon dioxide into the atmosphere (Heinberg, et al, 2009).

Declining productivity and viability

The ability to produce more food cheaply is a challenge that people have undertaken throughout human history and is one of the great strengths of industrial agriculture. However, a paradoxical reversal has taken place in the nature of agriculture since before the industrial revolution. Farming and forestry used to be society's primary net producers of energy requiring only the sun. Now, the food system is a net user of energy in virtually every nation and requires the expensive, polluting and finite energy inputs of fossil fuels. With the key to agricultural productivity and viability in the market economy now in decline, conventional agriculture faces a crisis in which producers are hard-pressed to turn a profit and consumers struggle to afford the increasing costs of food. In the meantime, increasing pressure on productivity exacerbates environmental consequences.

Vulnerability of oil-dependent farm systems

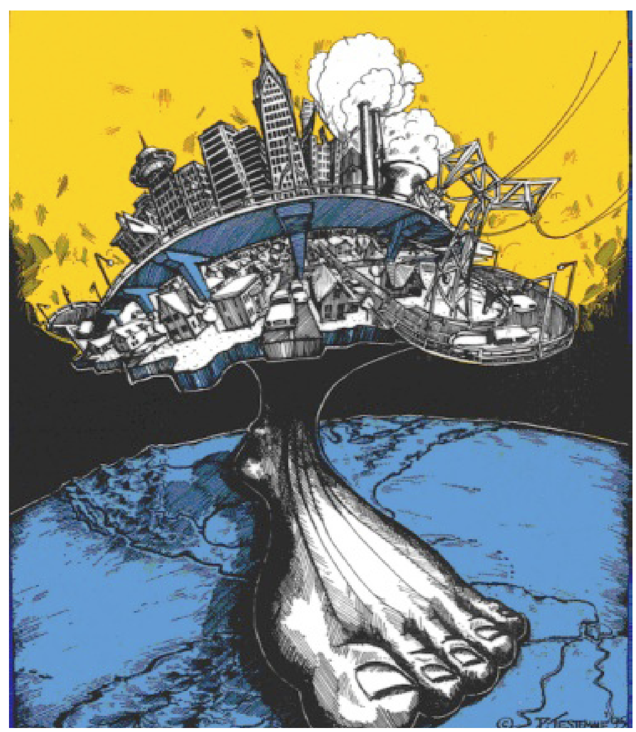
Perhaps the most fundamental transformation with the greatest consequences is the fact that agriculture has become depenedent on oil and natural gas, which are non-renewable fuels with increasing global demand and continually decreasing reserves. The peak year for discovery of new oilfields was 1964, and many nations, including the U.S. are in the decline phase of oil production (Heinberg et al., 2009).

The cost of food is a direct result of the cost of fuel, so when fuel prices rise in response to high demand and low supply, food prices also rise. Acute disruptions in supply coupled with economic downturn, crop losses due to drought or adverse weather, and growing demand would effectively produce the "perfect storm" capable of producing high food prices and widespread deprivation. A combination of these events is considered responsible for the food riots experienced in more than 30 nations in late 2008. "The only way to avert a food crisis resulting from oil and natural gas price hikes and supply disruptions while also reversing agriculture's contribution to climate change is to proactively and methodically remove fossil fuels from the food system." (Heinberg, et al., 2009)

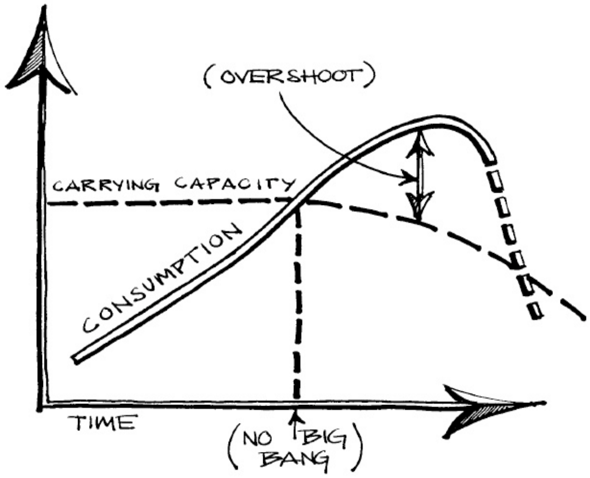
ECOLOGICAL FOOTPRINT

A significant ramification of industrial agriculture is the affect of changing land use on life in cities. With food production removed from cities and located in rural areas, the urban landscape can be dedicated to commercial activity and dense human settlement. The physical separation of urban communities from agriculture accommodates food production in the economy of scale and turns urban dwellers into consumers rather than producers of food. This shift has significant ecological and social implications. For example, dependence on imports directly translates into a city's expanded ecological footprint as well as attenuated food quality and availability conditions that are critical to the health and well being of urban communities.

The ecological footprint represents the total amount of land area needed to sustain an urban region. Carrying capacity refers to the maximum rate of resource consumption and waste production that can be sustained by a region without progressively impairing the ecosystem. The ecological footprint of



Ecologcial footprint
Source: Rees, William E.: Presentation to ISU Bioethics Program & Leopold Center for Sustainable Agriculture



Carrying capacity and overshoot
Source: Rees, William E.: Presentation to ISU Bioethics Program & Leopold Center for Sustainable Agriculture

Book cover featuring urban agriculture
Source: *The Transition Handbook*: from oil dependency to local resilience, Rob Hopkins, 2008

a contemporary city far exceeds its carrying capacity, so that it is dependent on importing the wealth and resources produced in other regions and exporting the wastes that it cannot absorb. Regardless of economic vitality, the city runs an unaccounted ecological deficit by importing resources and exporting waste (Rees, William E., 1992).

The ecological footprint and carrying capacity illustrate that sustainability requires ecological balance, shedding light on the need for reconciliation with economics that require exponential growth. Despite the challenge of generating empirical knowledge in terms of carrying capacity and ecological footprint, the concepts make it possible to see how urban agriculture projects can support resilience and sustainability of cities by positively influencing the flow of resources.
Using carrying capacity and the ecological footprint concepts to further emphasize urban agriculture's relationship to urban sustainability is one way to ensure that it has a place in contemporary discourse and on the agendas of planners, designers and community members. These metrics also have the potential to counter neoclassical economics and the linear input/output thinking that pervade the mainstream discussion of agriculture by offering a way to visualize relatively closed, cyclical resource movement and systems thinking. In this way, being able to think in terms of carrying capacity and ecological footprint represent an important paradigm shift that envisions resource production and waste decomposition as necessarily balanced; a perspective that aligns with some of the key goals and objectives of sustainable urban agriculture.

LIVABLE CITIES

While their high-density typology and existing infrastructure are well suited to efficiently meet demands for housing, transportation and services, the urban habitat often completely lacks adequate capacity to meet food needs. With agriculture largely removed from contemporary urban centers, cities rely on a globalized food system that is largely out of their control. Local food self-reliance, accessibility and quality must be regarded as an important piece of sustainable urban development. But rather than suggest that cities could or should produce 100% of their own food within city boundaries, this thesis recognizes urban agriculture as an important piece of a larger, regional and global scale transformation of the food system that can ameliorate fossil fuel dependency and the negative consequences associated with conventional modes of food production, processing and distribution.

Oil enabled the scale and distance of transportation of agricultural inputs and outputs to increase so that today, enormous amounts of food are routinely shipped to food-scarce cities dependent on trade to compensate for their ecological deficit. With consumers of food far removed from producers, the present day food system uses over four times as much energy as the singular act of farming. Approximately 7.3 calories are used by the U.S. food system to deliver each calorie of food energy (Heinberg et al., 2009). Keeping food miles to a minimum while increasing food security are important contributions to making cities 'livable'. Other factors include public services, transportation, education, social interaction, employment and economic activity, recreation and the presence of nature in the built environment. While urban agriculture often takes the form and serves the functions of green infrastructure, it is highly compatible with other green infrastructure elements such as parks and greenways and offers incredible potential to be formally integrated as such into the urban fabric. Moreover, it can provide a comparable model for making green infrastructure and urban open space more sustainable and livable.

With a long list of researched and recognized benefits, urban agriculture has major contributions to make toward the liveability and quality of life in cities (Deelstra, Tjeerd, et al.).

URBAN AGRICULTURE
Background and state of the art

Urban agriculture is a strategy in which local issues and global concerns may be embodied and managed creatively. Food systems analysts have contrasted local food production and markets with what has become in the mainstream "a dominant, long-distance, industrialized, highly concentrated, and globally reorganized system of food growing, processing, manufacturing, marketing and selling" (Gottlieb, 2002). It often takes advantage of underutilized and vacant space in the urban environment, serving as an informal approach to urban renewal. Its malleability lends itself to the uniqueness of each context in which it is born. In this way, it can offer a new sense of place and purpose for communities. A growing body of research is aimed at showing how urban agriculture projects can reduce a city's ecological footprint, ameliorate conditions of deprivation and resource dependency, and greatly enhance overall quality of life in cities (Garnett, 2006).

Its presence throughout history and its current, continued growth are the result of urban agriculture's ability to assist with the challenges of surviving in the urban environment (Mougeot, Thematic Paper 1). Urban agriculture is capable of supporting the livelihoods of human populations by means of diverse economies and productive practices. Indeed, this is what it has done throughout human history by being continually adaptable to meet human needs in a range of social, political, and ecological contexts. Urban agriculture takes various forms at different levels of urbanization. As cities become more urban, agricultural work is replaced by industrial and service jobs. Land becomes more valuable for buildings and infrastructure as density increases and people desire proximity to jobs and services. However, the opportunity to grow or acquire local food is essential to the ability to live and applies to all urban dwellers regardless of ethnicity, class and gender. The urban poor are not the only people who produce food, although they are more dependent on it for income and nutrition (Nugent, Thematic Paper 3).

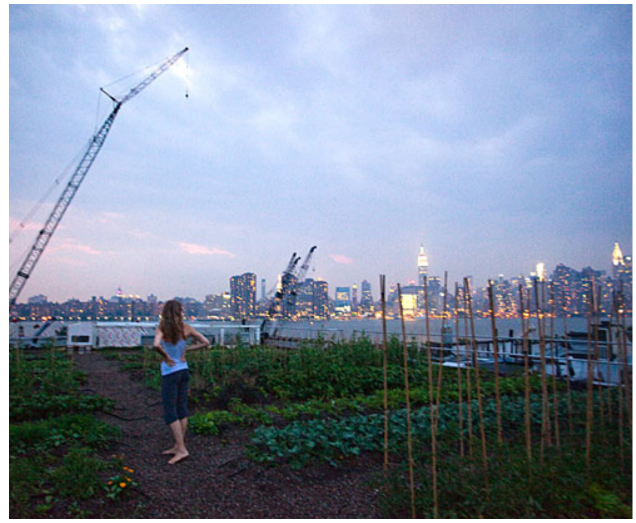
1939-1945, Sunday Morning, Clapham Common, London
Source: *CPULs,* Viljoen, 2005

Topography, climate, urban density, policy, resource availability, local cultural traditions, income, and household-level decisions will make a city more or less fertile for farming activity. The range of conditions gives way to a variety of urban agriculture manifestations. The combination of circumstances most likely to allow urban agriculture to emerge and make an important contribution to urban welfare can arise suddenly or develop over time; they can be temporary or permanent. Conditions in which food production suddenly becomes important include civil conflict, macroeconomic breakdown and natural disaster, often combined with high poverty, inadequate food imports, and good growing conditions. Urban-grown food may enter the formal market, while some may be bartered, given away and consumed by the growers (Nugent, Thematic Paper 3).

A suitable classification for urban agriculture consists of (i) subsistence home production, (ii) farm-type commercial production systems, (iii) entrepreneurial production systems, (iv) multicropped 'rurban' production systems (Moustier, 1999). Different kinds of technical systems exist within each group: roof top gardening, urban open space, hydroponics, aeroponics, aquaponics, organoponics, high-level input production, protected cultivation, and standard cultivation (de Bon, 2003, pg 356). These typologies will inform the selection of the case studies conducted later in this project.

While urban agriculture has traditionally functioned as a survival strategy for socially or economically marginalized populations, it is experiencing a renaissance in light of global challenges giving it contemporary relevance and additional purpose. As relocalization of energy and food resources becomes increasingly relevant, urban agriculture will be the primary front for the local food movement within cities. It is also serving as the stage for different players and interests groups to work together, for example, in the way that ReVision House, an urban farm and homeless shelter in Dorchester, MA., addresses food security, social justice, housing and job training for homeless women, through one project [1].

[1] See the website @ http://www.vpi.org/Re-VisionFarm/



Brooklyn's rooftop Eagle Street Farm
Photo by Michael Hanson
Source: www.grist.org

Novella Carpenter and her urban livestock in Oakland
Photo by Mark Richards
Source: www.time.com/time/photogallery

Starting in the early 1980's, efforts to address problems of industrial agriculture became politicized after unresolved differences led to diverging interests and agendas between sustainable and organic agriculture, small family farms, environmentalist and anti-hunger groups. However, despite the tendency for individual groups to carve out their own niches within a large issue in order to advance their own agendas, new players in the maturing counter-movement are emerging and reuniting groups through community food security, rural-to-urban and regional food shed approaches (Gottlieb, 2002). Rather than remaining exclusive to their respective camps, diverse organizations with seemingly different agendas have found success through collaboration. For example, farm-to-school programs show how the interests of public institutions can be merged with those of small, local farmers and food security groups, simultaneously addressing different aspects of a global problem through collective interest in local solutions. Urban agriculture is a premiere site in which global problem-solving strategies may be embodied collectively and locally.

Understanding and discourse

The variety of forms, functions and purposes, and the complexity with which social, economic and biological elements are integrated, make clear and easy definitions of urban agriculture challenging. Luc Mougeot, a prominent researcher on the topic, argues that an overarching definition should lead us into a full conceptual system or edifice that presents a structure of interconnecting compartments anchored into real-world experience. He is asking for a "conceptual yardstick" for measuring empirical manifestations and gauging how they reflect the concept at any given time or location. A conceptual yardstick is also needed to identify meaningful differences and gradations so that policy and technology interventions may appropriately promote and manage urban agriculture (Mougeot, Thematic Paper 1).

Developing such a tool for urban agriculture requires a set of customized value metrics in which empirical data reflect values outside of and in addition to neoclassical measures (e.g. unemployment, median family income). Values that represent social, ecological and informal economic benefits will be a powerful tool for substantiating claims regarding the productivity and sustainability of urban farm systems. This will become increasingly important in light of urbanization, demographic and environmental trends, and continuing concerns regarding social and economic development (Hovorka, 2003).

Reclaiming a role in the discourse of food production may be hard for a movement characterized by divergent systems and practices. However, as mainstream organizations and their leaders adopt sustainability principles such as reducing ecological footprint and supporting local economy, institutional policy and economic markets will begin to shift in favor of those alternatives. Illuminating divergent practices that have emerged in response to under-performing industrial agriculture and engaging them as problem-solving strategies will affirm their potential to aid in transition toward more high-yielding, sustainable food systems.

The hegemony of market-driven, industrial agriculture in forums such as the World Bank, IMF and contemporary mainstream economic discourse overlook sustainable agriculture movements. So-called ‘alternative’ modes of food production, including urban agriculture, are up against a status quo which assumes them unfit to meet the demands of global populations and lifestyles (Gottlieb, 2002). While that assumption may be valid in the here and now, it does not absolve the status quo from pursuing wider-scope, longer-term alternatives and identifying the most appropriate, meaningful and productive role(s) for urban agriculture, now and in the future.

OUTCOMES AND BENEFITS

Social

The social-cultural benefits are perhaps emphasized the most in the literature on urban agriculture. Viljoen, Bohn and Howe recognize that urban regeneration, reduced discrimination and crime, and increased economic activity are some of the social-cultural benefits of urban food growing. Its ability to make a visible difference in quality of urban life has been documented in literature from North America and Europe (Garnett, 1996, Howe and Wheeler, 1999, Hynes, 1996). Urban agriculture provides purposeful, productive, social activity for groups who are often discriminated against or marginalized.

Social value metrics that may be used in the comparative analysis and assessment model include: education, food availability and affordability (food security), dietary diversity, reduced crime, improved individual well being, and community cohesion.

Ecological

According to Viljoen, Bohn and Howe, the ecological benefits of urban agriculture include preserving biodiversity, handling waste and reducing the amount of energy used to produce and distribute food (Viljoen et al., 2005). Urban agriculture projects perform valuable ecosystem services such as providing wildlife habitat, capturing and infiltrating stormwater, reducing heat island effect, and sequestering carbon dioxide. Many of these ecological benefits are also economic benefits in the form of cost savings opportunities for individuals, municipalities and businesses.

Red wigglers decompose food waste at Growing Power
Photo by Ryan Harb

For example, the ability to recycle organic waste creates a significant diversion from the waste stream and reduces the potential costs associated with disposal and landfill. Reduced stormwater runoff due to increased soil infiltration helps protect nearby streams and water bodies from erosion and pollution while reducing the need for costly storm water infrastructure and management. Improved air quality brought on by urban agriculture activities may contribute to the health and productivity of the population and produce cost savings in health care.

Ecological value metrics that may be used in the comparative analysis and assessment model include: reducing embodied fossil fuel energy of food, recycling waste, providing wildlife habitat, and supporting air, soil and water quality local and globally.

Internalizing costs and comparative advantage

Ecological benefits that translate into cost savings are considered external economic benefits. Different from linear production-consumption economic models that don't take environmental costs or 'ecological deficits' into account, regenerative urban agriculture practices are, in effect, absorbing and remedying ecological deficits (for example, topsoil erosion and excess atmospheric carbon dioxide) generated by human activity. Internalization into the market of the external costs associated with conventional agriculture would give urban agriculture produce additional comparative advantage over similar produce that is imported or comes from unsustainable production systems. Further research activities need to be developed to explore urban agriculture's comparative advantages of proximity to the market in a context of globalization and agricultural trade liberalization (de Bon, 2003). Comparative advantage will be an important consideration for enterprises as growing global ecological deficits continue to put pressure on business as usual, and the once 'alternative' or 'niche' markets favoring business characterized by ethical production, manufacturing and marketing practices become more mainstream.

Policy changes at the regional, national and international levels are needed to overcome structural barriers and distorted markets in the urban food supply system (Petts, 2005). Small-scale enterprises operating according to sustainable and ethical practices would be encouraged by the comparative advantage produced by the internalization of external economic costs and benefits of food production. This process of internalization could employ appropriate standards, incentives, subsidies, taxes and regulations in order to shift the profitability calculus in favor of sustainable practices and breathe even greater life into local food systems.

Such a shift would make it possible to establish an enterprise on the principle of eco-effectiveness in which the process of production is based on "doing the right thing", or in other words, is socially and environmentally responsible. Eco-effectiveness must go hand in hand with eco-efficiency, which seeks to "do more with less"; an essential principle for enterprise whereby outputs increase and inputs decrease (McDonough & Braungart, 2002). In other words, criteria for successful and sustainable enterprise include the ability to produce in abundance through practices that are socially, environmentally and economically responsible.
Comparative advantage is a benefit to urban agriculture by offering the incentive and potential to meet these criteria as part of an alternative, ecological economy that helps meet the needs of present generations while preserving and restoring natural resources for future generations to meet their needs.

Economics
The formal and informal economies

The formal economic benefits afforded by neoclassical indicators include employment, income generation and enterprise development (Smit, 1996). Also, food production can lead to significant savings in household budgets, making that portion of the family income available for other expenditures. Food surpluses are often sold, augmenting the incomes for families and enterprises, which may in turn be used to initiate new investment opportunities (Petts, 2005).

But research on the subject overwhelming agrees that, as an 'alternative' economic entity, many of its values and benefits are obscured by neoclassical economics. Although they are fundamental to the health and vitality of the total productive system of an industrial society, benefits contributing to quality of life are difficult to quantify and traditionally unaccounted for by the official market economy.

Urban agriculture has an intrinsic relationship with the informal economy. It represents an altogether different approach to food and lifestyle than that which is underpinned by the formal, market economy.

While not necessarily limited to alternative or informal economic manifestations, urban agriculture economies lend themselves to bartering, volunteering, mutual aid and home-based production. Practices are typically rooted in relationship to nature and foster the diverse and abundant means of creating a livelihood that characterize the informal economy. Hazel Henderson's illustration of the total economy of an industrial society as a layer cake with icing is helpful for conceptualizing the urban agriculture economy in relationship to the official market economy (See *Total Productive System of an Industrial Society (Layer Cake with Icing*), Appendix). Similarly, urban agriculture may more reasonably align with the values encompassed by 'community economy' as presented by J.K. Gibson-Graham in the list of keywords characterizing the mainstream and alternative economies (See *Key words of economy and community economy*, Appendix). As an 'alternative economy' urban agriculture is generally viewed as not profitable compared to other economic activities and urban infrastructure, but that cities prefer to maintain agricultural activity for its other contributions to urban quality of life.

On the other hand, a livable city must provide means of earning a living and meeting basic needs, whether within or outside of the formal market economy. As cities grow, the need for new jobs places huge demands on the urban economy, often in the face of existing unemployment. When the job market cannot keep up with growth, or the formal economy experiences downturn, urban poverty rises. Many people find work in the informal sector, where they may move easily and often from one job opportunity to the next and participate in a range of exchange practices that are need-oriented, rather than profit-oriented. The population of informally employed is growing absolutely and relatively in cities across the world. An estimated 56% of urban employment throughout Africa is based in the informal sector, as is 40% in the Asia/Pacific region and 30% in Latin America (UNCHS, 1999). Agriculture is one of the activities that urban dwellers, especially the urban poor, turn to (Nugent, Thematic Paper 3).

The dimensions of the economy traditionally not seen or accounted for may be revealed by using strategies such as 'adding on' and 'counting in'. These strategies can generate representations of a totally new economy that is perhaps more real or 'whole' because it appreciates the creativity, productivity, resilience and solidarity that exist outside and along with mainstream economics (Cameron, Gibson-Graham, 2003). These strategies are relevant to the project of finding and understanding urban agriculture economies happening outside of the formal economy.

Still, urban agriculture as a profit-oriented system participating in the formal economy is different than a quality of life-oriented system operating in the informal economy. Therefore, the question of economic benefit and viability depends entirely on what economic stance is taken, which criteria for evaluation is selected, and how that criteria is prioritized. For this reason, the method developed for this project has expanded the traditional, evaluative framework by 'adding on' the diverse economy as an essential economic outcome of urban agriculture.

The relationship

Some historical perspective on economic evolution is necessary for understanding the divergence and stratification of what is seen today as distinctive economic realms: the formal market economy and the informal economy. In *The Great Transformation*, Karl Polanyi describes how the economy used to be imbedded within historic, complex and instructive social order but became detached in order to foster a 'competitive capitalist economy' capable of generating inconceivable material wealth. Polanyi argues that this economy, focused on maximum creation of capital, does not completely express the qualities of land, labor and money, and subordinates society to its definitions and laws. Its separation from, and subordination of, the fabric of society produces massive socio-economic dislocation by compelling the abandonment or adaptation of traditional economic practices and relationships in the process of reorienting the focus of society toward the ‘competitive, capital-oriented economy’ (Polanyi, 1944).

This ‘great transformation’ as Polanyi puts it, meant that the informal economy, where traditional practices based on cooperation, trade and mutual well-being prevailed, would become subordinate to the market economy, where competitive, profit-oriented models of production and consumption led to unprecedented enterprise activity, wealth generation and social and environmental devastation.

Industrial modes of production and processing have given way to changes in the marketing and selling of food so that advertising and the ability to make an impression in national or global markets are now critical to economic survival. For example, a broad pattern has been identified in the U.S. where small farmers have been bypassed by large-scale agri-business, manufacturing conglomerates and supermarkets (Cook et al., 1996) and research shows that the decline in small-scale local food shops coincides with the rise of food retailing giants and out-of-town markets in Britain (Howe, 2005). In this way, the market economy can be hostile or exclusive to small, unconventional enterprises that are not geared for doing business in large, competitive markets or producing at industrial scale. The relationship between small scale food production enterprises (including urban agriculture) and the formal market is antagonistic as the market is distorted to favor competitive and industrial models in virtually every regard: production, processing and manufacturing, distribution, marketing and retailing, even waste management.

The relationship between the formal and informal economy is both symbiotic and antagonistic. Depending on how they are delineated, either can be seen as dominant. Today, participating in the formal economy is virtually imperative when it comes to making a living; an imperative that is often disfavorable to alternative enterprise. However, the formal economy is deeply supported and complemented by the informal economy, which keeps people healthy and able to work in good macroeconomic times, and enables them to survive in poor macroeconomic times through needs-based practices such as self-provisioning, mutual aid, barter, and agricultural productivity.

Farm system productivity

Research has largely focused on socio-economic benefits and policy surrounding urban agriculture. There remains an information gap on the topic of agricultural productivity (Cleveland, 1997). Perhaps least developed is the knowledge on differentiated production practices, their distinct capacities, strengths, weaknesses and yields. Conventional production-consumption models that do not take long-term health of natural and social systems into account are insufficient for the necessary task of fully realizing urban agriculture's productive potential. In the mean time, they serve as a major limitation to the appropriate adoption and proliferation of urban agriculture practices by producing incomplete assessments that portray urban agriculture as an inferior land use and economic activity in terms of efficiency or productivity.

Differentiating between farming systems within an appropriate, custom framework for understanding productivity outside and in addition to agricultural productivity can illustrate, verify and validate the productive potential of urban agriculture via its quality, diversity, adaptability and multiple other benefits.

Agricultural yield as a function of productivity, cost of inputs vs. outputs (efficiency), and the market value of produce are traditional indicators for urban agriculture farm system analysis. Unconventional values, such as the ability to yield long-term health of natural and social systems, in addition to biological productivity should be taken into consideration (Dahlberg, 1998). Hellwinckel and De La Torre Ugarte have identified three essential characteristics of farming systems that meet Dahlberg's criteria. Through regenerative practices, these systems have the ability to 1) sponsor their own energy, 2) build soil, and 3) produce in abundance (Hellwinckel and

De La Torre Ugarte, 2009).

Given their different goals and objectives, profit-oriented systems will relate more to quantity and profitability of market products, while systems focused on beneficially influencing quality of life require unconventional valuation and assessment. In both instances, two essential problems remain 1) the response of the system to demand by consumers, and 2) the relationship between the system and the urban environment (de Bon, 2003, pg 362). Regardless of different goals and objectives, a holistic integration of economic, social and ecological well–being must be intrinsic in urban agriculture farming systems. Perhaps because of its unique location at the intersection of culture, nature and the built environment or because of its roots in the informal economy, criteria that make urban agriculture projects socially and ecologically viable also tend to reinforce its economic viability.

This is the premise of financial permaculture: the entire system and its parts are optimized. In this way, the social, ecological, and economic elements of the farming system are engaged with greatest efficiency to generate the least amount of waste for the highest yield while taking into account the true social and ecological costs (Dauksha-English, 2008). Furthermore, financial permaculture correlates 7 standard investment principles with 24 permaculture principles, and in doing so helps to establish theoretical common ground between these evidently irreconcilable belief systems (See *Comparison of investment and permaculture principles,* Appendix).

Methods

A NEW FRAMEWORK FOR COMPREHENSIVE ANALYSIS AND ASSESSMENT OF URBAN FARM SYSTEMS

From traditional to state-of-the-art systems, urban agriculture comprises many different styles, practices, and modes of production. The tremendous range creates the need for better articulation and more accurate distinctions between actual urban farm systems. In order to better understand advantages and disadvantages, and the significance underlying differences and similarities, a comprehensive analysis and assessment method is needed. Such a method makes it possible to conduct evaluation of discrete cases, as well as draw meaningful comparisons.

Previous research has focused largely on understanding a small number of social and economic impacts of urban agriculture. The new framework is expanded to include additional social and economic benefits, ecological benefits, and gross agricultural yield as other, critical outcomes of urban farm systems. Furthermore, outcomes and benefits have been linked to their foundation in the design and dynamics of urban farm systems. There is minimal explicit analysis of designed urban agricultural systems within the academic literature, and no holistic framework exists to ascertain the influence of design on outcome and benefits by means of a vital set of dynamics. This new, comprehensive framework makes it possible to analyze and assess local and global impacts and trace them to individual design decisions (Figure 3 - 1). Understanding the web of influences within urban agriculture assists in designing new systems and informs the adjustments needed to optimize existing ones.

VALUE METRICS AND ASSESSMENT CRITERIA

This comprehensive analysis and assessment method uses value metrics for farm system analysis. These value metrics are mapped out within their respective farm system dimension: design, dynamics, outcome and benefits (Figure 3 - 1). For explanations and definitions of each metric, please

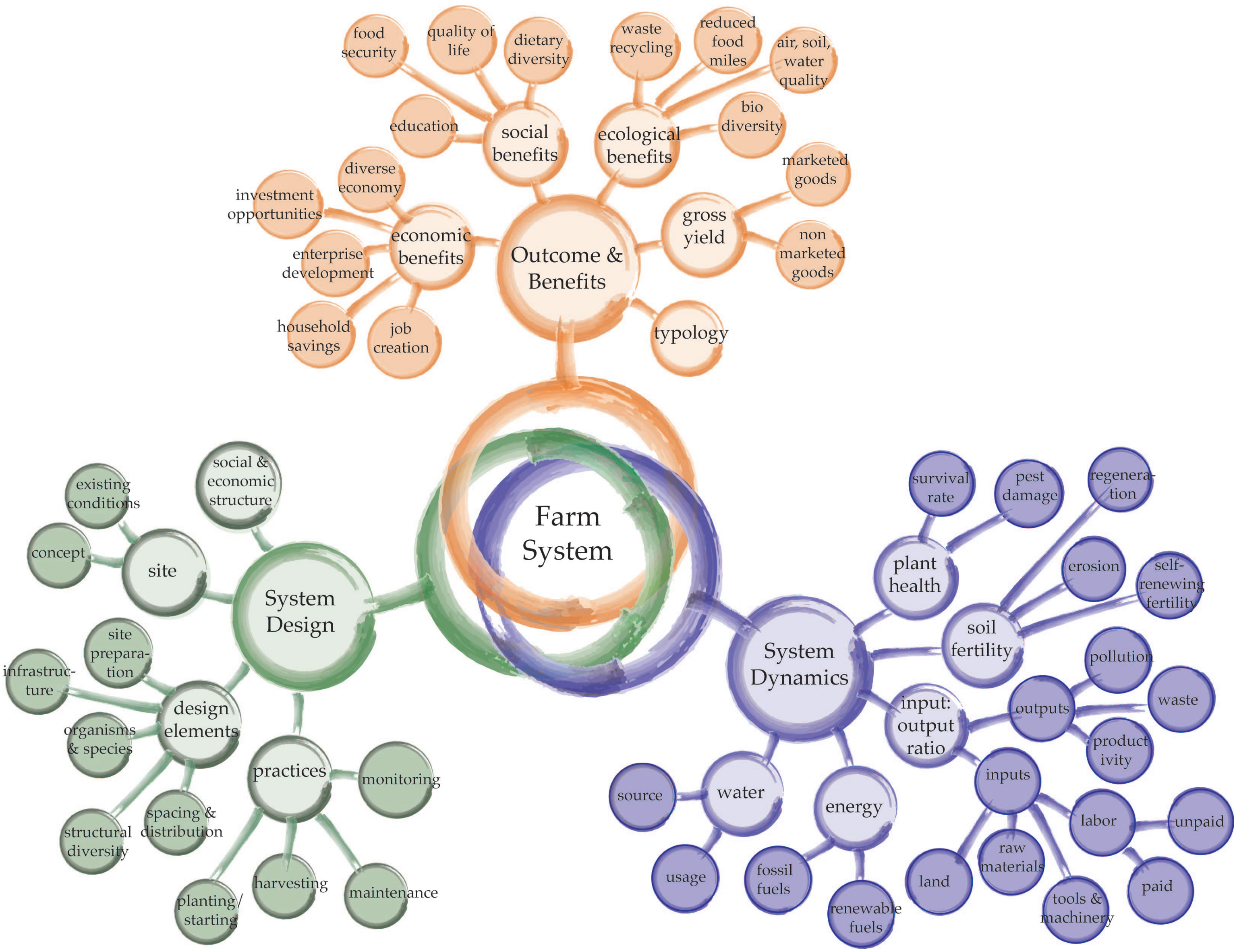


Figure 3 - 1
Comprehensive evaluative framework

see Appendix. Value metrics are the relevant data or information concerning the farm system, and they may take different forms: numeric value, qualitative description, visual illustration, a trend indicated as increase/decrease, or the presence/absence of something indicated as yes/no. Methods for collecting data include site visits and site analysis, design process analysis, interviews with designers, managers, employees and interns, and general information gathering from the library and web-based sources.

DATA | ASSESSMENT CRITERIA

System Design

▪ = low ■ = medium ■ = high

	VALUE METRICS		description	intensity	diversity	Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
Site	existing conditions																
	concept																
Design Elements	site preparation																
	infrastructure																
	structural diversity																
	organisms & species																
	spacing & distribution																
Practices	planting/starting																
	harvesting																
	maintenance																
	monitoring																

Figure 3 - 2
System design assessment matrix

A survey sheet was generated for the process of collecting and organizing the information needed for farm system analysis (see Appendix). As needed, this survey may be adapted to more explicitly analyze different attributes of an urban farm system.

System Dynamics

▪ = low ■ = medium ⬛ = high □ = zero

Y = yes **N** = no

	VALUE METRICS	DATA: description	yes/no	usage	cost	output	percent of crop	ASSESSMENT CRITERIA: Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
Water	source																		
Energy	fossil fuel																		
	renewable fuel																		
Soil fertility	self-renewing fertility																		
	erosion																		
	regeneration																		
Plant health	survival rate																		
	pest damage																		
Input:Output ratio	raw materials																		
	land																		
	tools & machinery																		
	labor																		
	productivity																		
	pollution																		
	waste																		

Figure 3 - 3
System dynamics assessment matrix

Twelve assessment criteria are used to evaluate farm system performance. Assessment criteria, their rank and importance may be adapted and customized as needed to incorporate the goals and objectives of a particular farm system and to better support the aims of different research projects.

Outcome & Benefits

▪ = low ■ = medium ⬛ = high

🡅 = increase 🡇 = decrease

Y = yes **N** = no

	VALUE METRICS		DATA: description	DATA: yes/no	DATA: increase/decrease	DATA: annual total	DATA: annual cost savings	ASSESSMENT CRITERIA: Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
	typology																		
Economic benfits	enterprise development																		
	investment opportunities																		
	household savings																		
	job creation																		
	diverse economy																		
Ecological benefits	waster recycling																		
	reduced food miles																		
	air, soil, water quality																		
	biodiversity																		
Social benefits	dietary diversity																		
	education																		
	quality of life																		
	food security																		
Gross yield	marketed																		
	nonmarketed																		

Figure 3 - 4
System outcome and benefits assessment matrix

Once the data has been gathered, assessment criteria are applied using a matrix so that each value metric is cross-referenced with each assessment criteria (see Appendix). The matrix makes it possible to evaluate every aspect of the farm system based on data, rank performance in terms of "low", "medium", or "high", and determine what aspects warrant further investigation or elucidation. The ability to scrutinize all aspects of the farm system from a single perspective is this method's strategy for revealing capacities, strengths, weaknesses, best practices and key lessons.

DERIVATION

As stated previously, information on farm system design and dynamics was not found within the urban agriculture literature. This information was drawn from the seminal text on sustainable and regenerative food production systems, *Edible Forest Gardens* by Dave Jacke [2]. The value metrics were drawn from literature on urban agriculture (R. Nugent), common agricultural practice, permaculture, forest gardening, agroecosystem analysis, landscape architecture, urban planning, and neoclassical and informal economics. They represent accepted practices and terminology from those specialties.

The assessment criteria were developed to encompass contemporary best practices and objectives as identified by the current literature on sustainable agriculture, permaculture, urban design and planning, and the convergent crisis' of industrial agriculture, peak oil and unsustainable urban ecological footprints. This project applies a preliminary set of assessment criteria grounded in the values of present-day, sustainability-driven specialties.

While they may be viewed as difficult to measure, idealistic or abstract, the criteria are capable of assessing farm systems at site-scale, within city-scale

[2] Figure 1.1 of Volume Two furnished the content and inspired the organization of system design and dynamics, and several of Jacke's design elements & ecosystem dynamics have been modified or consolidated for inclusion.

context. In this way, the assessment criteria effectively link local actions to global impacts; another critical connection needed by urban agriculture to stake out and validate its role in sustainability. For example, the ability to capture waste from the urban waste stream is a site-scale function with measureable, city-scale impacts.

Finally, the value metrics and assessment criteria garnered from the broad literature to generate this framework were tailored for urban farm systems. However, the framework may be applied to any endeavor aiming for sustainable and resilient regenerative agricultural, or more specifically, seeking to maximize agricultural productivity through designed complexity that integrates diverse modes of production while minimizing the need for human intervention.

Case Studies

Growing Power, Inc. and the Holyoke Edible Forest Garden are case studies for this project. These two examples of urban agriculture were selected because they are near-opposites in the spectrum of model farm systems: Growing Power modeled after a traditional, family farm in the Midwest, and the Edible Forest Garden modeled after a mid-succession, forest ecosystem reclaiming an abandoned KMart parking lot in Holyoke. Both are leading examples of their respective type of urban agriculture.

Growing Power headquarters storefront featuring a new photovoltaics solar array
Photo by Ryan Harb

GROWING POWER

A leading example of contemporary urban agriculture, Growing Power consists of a two-acre headquarters with three accessory, suburban plots in the city of Milwaukee, WI. The headquarters site is zoned agricultural within a densely settled, residential neighborhood located 5 -10 minutes by car to the city center. The site is within plant hardiness zone 4, where temperatures fall to between 0 and 20 degrees farenheit at night in the winter. Existing buildings and infrastructure include a storefront, six glass greenhouses, three farmhouses and a large barn. Nine hoop houses, multiple animal shelters, massive compost piles, refrigeration trucks and a solar array have been added.

Will Allen leading one of many educational workshops
Photo by Ryan Harb

Founded in 1993 by entrepreneur, Will Allen, the original program was designed to offer employment opportunities to local youth. Since remediating the site, restoring the original greenhouses and buildings and initiating multiple modes of agricultural production, the project has evolved to become a prominent, local food source offering critical social, ecological and economic benefits locally and nationally. Its theoretical underpinning includes supporting sustainable relationships between people from diverse backgrounds and their environment by improving access to healthy, high-quality, safe and affordable food.

Steamy warm greenhouse in the dead of winter
Photo by Ryan Harb

Growing Power now specializes in youth development and community engagement, local employment, farm system training, education and technical assistance, waste recycling and compost

Winter greens growing in the unheated hoop houses
Photo by Ryan Harb

Growing Power offers 3 different kinds of "market baskets" to suit different budgets and family sizes
Source: www.growingpower.org

production, and community food security. These activities proactively respond to local conditions in which wholesome, unprocessed foods are geographically or economically unattainable for many neighborhood residents, while education and employment opportunities are lacking. Having a broader impact are the on-site demonstrations and hands-on trainings that empower visitors with the knowledge to develop their own sustainable community food systems by growing, processing, marketing and distributing food (www.growingpower.org).

There is a hierarchical social structure at Growing Power in which managers, employees, interns, and volunteers assume different roles and responsibilities based on their skills, knowledge, and experience. For example, managers and paid staff are responsible for decision-making and facilitation of farm system management, while interns and volunteers primarily carry out the physical implementation and maintenance of projects. In this way, farm system complexity is managed by delineating the work and delegating it to particular individuals or groups.

In terms of economic structure, Growing Power employs multiple economic models. It functions as a market enterprise, national non-profit and a landtrust. In addition to selling goods via its store and website, it uses a community supported agriculture (CSA) model for marketing and distributing its goods. Each economic model serves a different function, but all contribute to the purpose of generating capital. Being equipped with multiple means for obtaining an income increases the amount of economic transactions that Growing Power can be a part of as well as the amount and variety of services it can offer.

Growing Power sitemap
Source: www.growingpower.org

View of backyard from house
Photo by Eric Toensmeier

View of house from the forest garden
Photo by Eric Toensmeier

Perennial polyculture with pawpaw, asters and comfrey
Photo by Eric Toensmeier

HOLYOKE EDIBLE FOREST GARDEN

The Holyoke Edible Forest Garden is located in the backyard of a two-family home in a medium density neighborhood, in the city of Holyoke, Massachusetts. The site, measuring approximately 45 x 90 ft.., is within plant hardiness zone 6; relatively warm for the region as a result of urban heat island effect and its low elevation in the Connecticut River Valley.

Primarily a shared, personal garden for the household residents - Eric Toensmeier, Jonathan Bates, and family – the "urban forest garden is an intensively managed, backyard foraging paradise, a megadiverse living ark of useful and multifunctional plants… and is the unifying element of a larger permaculture design for food production, wildlife habitat, and social spaces that encompasses the entire property" (http://permaculturenursery.com/goals.htm) Their aim is to maximize agricultural yield and reap social, ecological and economic benefits by gardening every inch of the site and extending productivity throughout the year. A small hoop house, chicken coop and toolshed are the newest infrastructure helping them achieve their goals. The theoretical underpinning is to demonstrate permaculture and edible forest gardening at the backyard scale by experimenting with high yielding, perennial polycultures (perennial plants grown in dense patches) and annual crops. Their goal for agricultural yield is a double-handful of preferred fruits and veggies/person/day.

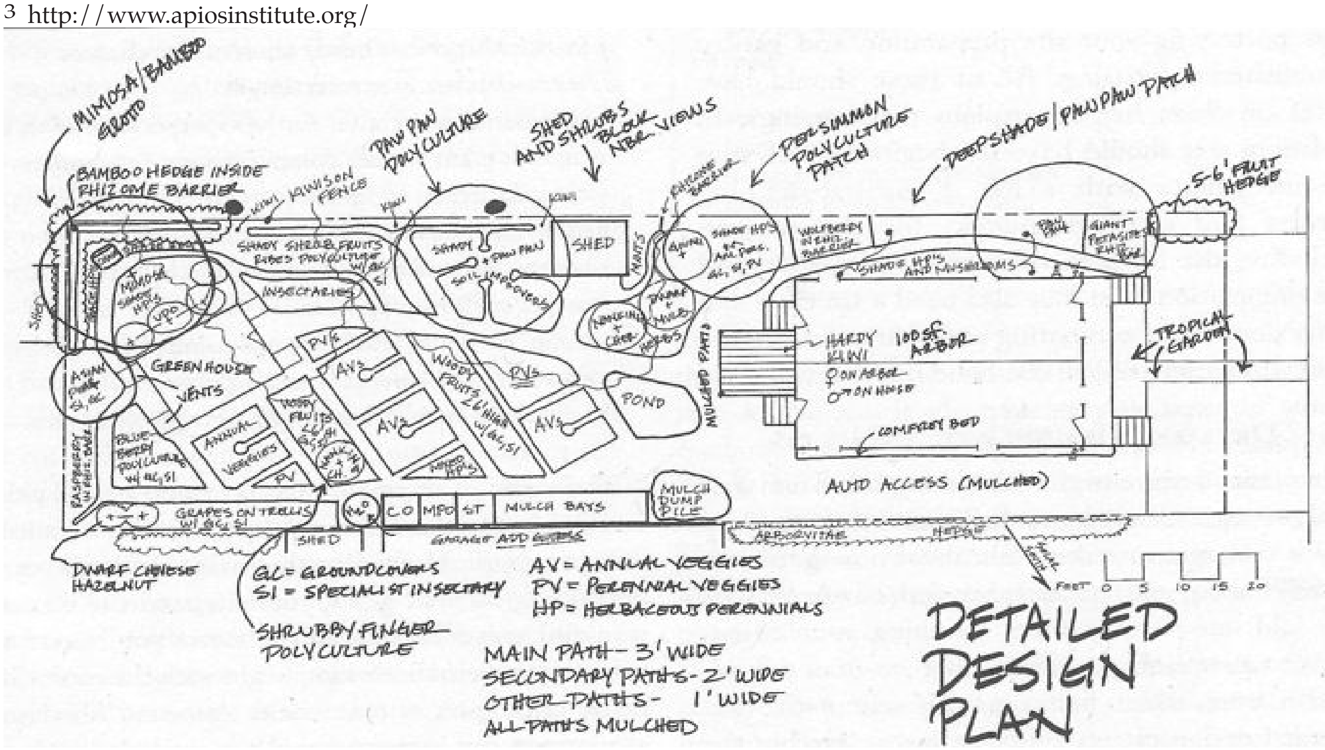
The social structure is informal and non-heirarchical, so people are able to negotiate about the ways and the extents in which they participate. Decision-making, management and maintenance happen, more or less, collectively.

Like Growing Power, the Holyoke Edible Forest Garden has more than one economic structure whereby different services are compensated through formal and informal means of exchange. Its agricultural yields are mostly used for subsistence; an informal economic benefit. It also serves educational and enterprise purposes: in addition to neighbors and passers-by, over 1,000 students within the past 5 years have visited the Holyoke Edible Forest Garden and participated in workshops to learn permaculture and forest gardening. And the numbers keep growing. The project is a major focal point for the Apios Institute; a website showcasing their work and offering extensive information on forest garden design and the horticulture of perennial, food producing plants, including publications by Eric Toensmeier [3].

Finally, more than six years of growth and development in the Holyoke Edible Forest Garden has led to a healthy stock of high-yielding, low-maintenance, and otherwise beneficial, food-producing perennials. Jonathan Bates has since become the entrepreneur of a new nursery enterprise specializing in plants suitable for forest gardens in the region. In sum, the forest garden has given rise to a variety of related professional endeavors - education, business, research, and literature – run by the proprietors in addition to the work of cultivating the garden.

3 http://www.apiosinstitute.org/

Some of the diverse yields of the forest garden
Photo by Eric Toensmeier



Holyoke Edible Forest Garden sitemap
Source: Eric Toensmeier

Application

The strategy of this project was to conduct comprehensive analysis and assessment of both case studies using the method described in Chapter 3. Each farm system was analyzed using interviews and site visits to gather the maximum information achievable within the project's scope. The process of transcribing the information into the matrices revealed the significance of different design strategies, their influence on system dynamics, outcome and benefits and their overall strengths and weaknesses. Subsequently, a limited number of farm system attributes, or "foci" were selected for comparison and/or individual illumination. These foci were selected because they were the most interesting, held fundamental significance and featured valuable key lessons regarding sustainable urban agriculture. Since farm systems are complex and three dimensional, the application utilizes different media to convey findings including descriptive text, diagrams and illustrations.

COMPARATIVE ANALYSIS AND ASSESSMENT USING CASE STUDIES

System design

Organisms and species and structural diversity were selected from System Design for comparative analysis and assessment. While all aspects of system design are important, these two are perhaps the most influential on the rest of the farm system. The case studies feature contrasting applications of organisms and species and structural diversity, producing rich discussion and key lessons regarding those attributes.

Organisms and species

The organisms and species cultivated at Growing Power include goats, chickens, ducks, fish (perch and talapia), worms, bees, annual plants, and a turkey. With the exception of the aquaponics systems (discussed in self-renewing fertility), the plants and animals are raised as discrete modes of production. This strategy offers certain advantages: contained spaces make it possible to regulate the needs and behaviors of the plants and animals, and consequently, the density of their populations and overall productivity. At the same time, separation

Growing Power's goats and hoop houses: truly a farm within the city
Photo by Ryan Harb

Many chickens live together in their own hoop house
Photo by Ryan Harb

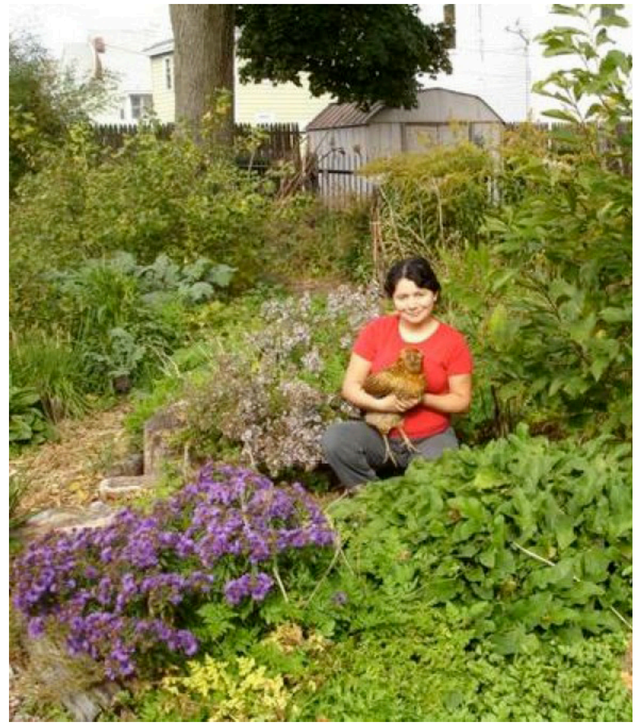
makes the plants and animals unable to enact beneficial behaviors as interdependent functions of the system. For example, chickens and goats could be used to control pests and invasive plant species as well as help restore soil fertility with their nutrient-rich deposits. Instead, they rely on the farmer workers to provide their needs, harvest their yields, remove their wastes, and recycle their inputs. This constitutes a huge amount of routine farm system maintenance reducing the efficiency of the farm system.

At Growing Power, approximately 120 chickens share a 20′ x 40′ hoop house. 100 percent of their food must be provided and waste removed. The chickens perform their valuable ecological role of consuming food scraps and producing nitrogen-rich wastes, but it requires the utmost intervention by human hand. Furthermore, additional inputs are required to abate the smell that results from the concentrated and unchanging nature of the chicken house. Similarly, the goats, turkeys and ducks remain in designated pens, and their inputs and outputs require complete facilitation by workers.

Growing Power's emphasis on farm-style animal husbandry is viable due to its larger site and ample supply of workers. In fact, demand for labor is a positive outcome within the farm's socio-economic context and meets one of its original objectives; to provide jobs for neighborhood youth. While it may be inefficient in terms of sheer productivity, the organisms and species at Growing Power provide jobs, education and training. Furthermore, the production of fresh meat and eggs is another critical outcome accomplished in response to one of the threats of the context; lack of places to buy fresh, whole food. In summary, Growing Power's organisms and species demonstrate a kind of functional separation, that is high-maintenance by design and accomplishes a variety of critical objectives.

By contrast, the Holyoke Edible Forest Garden has just three chickens and instead emphasizes an extremely high amount and diversity of edible, annual and perennial plants. The forest garden is home to over two hundred types of perennial species, in addition to which all of the farm's annual crops are produced during the growing seasons. As a result of careful design, the special adaptations of the different plant species in the Edible Forest Garden are optimized within the system. These functionally interconnected plant communities, called guilds, partition available resources into layers where they can be effectively put to use by the different plants (Jacke, Volume 2). The species' complementary characteristics allow them to automatically meet their own needs without competing and require little maintenance. This type of farm system, called forest gardening, mimics the form and function of a forest edge: a densely vegetated, extremely productive ecosystem found in nature. The concept even applies to the chickens, which at certain times of year are allowed to roam the garden, freely forage for food in the understory and fertilize the soil under the protection of the fruit and nut tree canopy.

The two case studies demonstrate drastically different design approaches to farm system organisms and species. They are distinguished by their different emphasis' on plants and animals, use of biodiversity and ecological niche, level of designed integration between species, and the resulting affect on labor, dietary diversity and social/economic benefits. The key lessons are that organisms and species are primary design elements that majorly influence the rest of the farm system. In addition to suitability for the physical site, organisms and species must appropriately respond to the availability of human power. Selection of organisms and species is as an opportunity to generate desired social and economic benefits such as education and employment in addition to agricultural yields. Finally, the level of integration between organisms and species is a fundamental design strategy that can be used to increase or decrease a farm system's maintenance according to its goals and objectives.



Chickens are a useful design element that requires less maintenance and offers more benefits when integrated with the rest of the farm system
Photo by Eric Toensmeier

Dwarf mulberry, jostaberry, comfrey, kale and sage grow in polyculture around an "early golden" persimmon tree
Photo by Eric Toensmeier

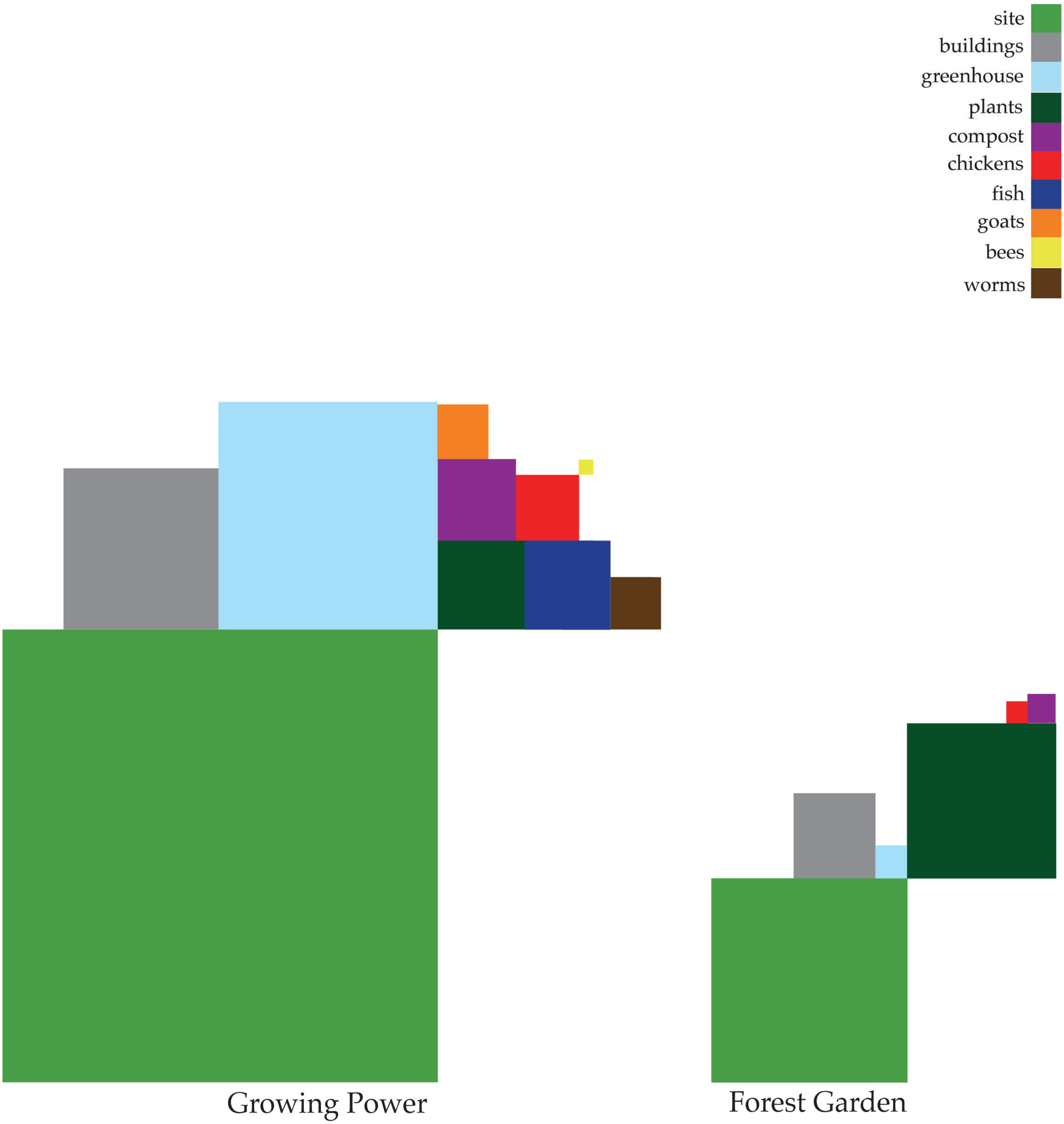


Figure 4 - 1 Proportional comparison of organisms and species
With a much larger site, Growing Power raises more animals, while the forest garden boasts over 200 plant species. Both farm systems satisfy the criteria: to produce abundant, complementary yields, regenerate organic matter and topsoil, renew fertility and inputs within the system.

Structural diversity

Growing Power's intensive infrastructure is comprised of multiple farmhouses and greenhouses, animal shelters, support structures, water tanks, pipes, pumps, lighting, heating and refrigeration units, and as of May 2010, a brand new solar array. Among other things, this infrastructure provides the means for achieving structural diversity. All productive elements (plants, animals, insects) rely on some kind of physical structure for shelter, support, or the ability to perform critical functions such as photosynthesis. Growing Power achieves multiple layers of productivity through vertical space by overlapping, stacking and suspending modes of production.

Its best examples are its greenhouses, where fish occupy tanks, on or submerged in the ground plane, while assorted sprouts and greens grow on three or four horizons above. Hundreds of plastic flowerpots loaded with fresh greens are stacked against walls and suspended from greenhouse framing, effectively creating a "green wall" of edibles. The different organisms - fish, sprouts and salad greens - are each located in a customized niche that enables them to be productive.

At Growing Power, the infrastructure is an effective strategy for overcoming the limitations of producing food in a cold climate, on a physically constrained, urban lot. It makes it possible to produce food where there is no access to soil, and diversify crops by creating a variety of productive niches. The main drawbacks include construction costs and the need for a higher skill level among staff. Another consideration is the fact that infrastructure is, itself, not agriculturally productive. So, infrastructure-dependent systems must be many times more productive to over-compensate for the time, energy, money, and space invested in sheer infrastructure. Ultimately, good design and engineering can lead to farm systems that are exponentially more productive than those without built infrastructure.

Nasturtiums in hanging pots form a "green wall"
Photo by Ryan Harb

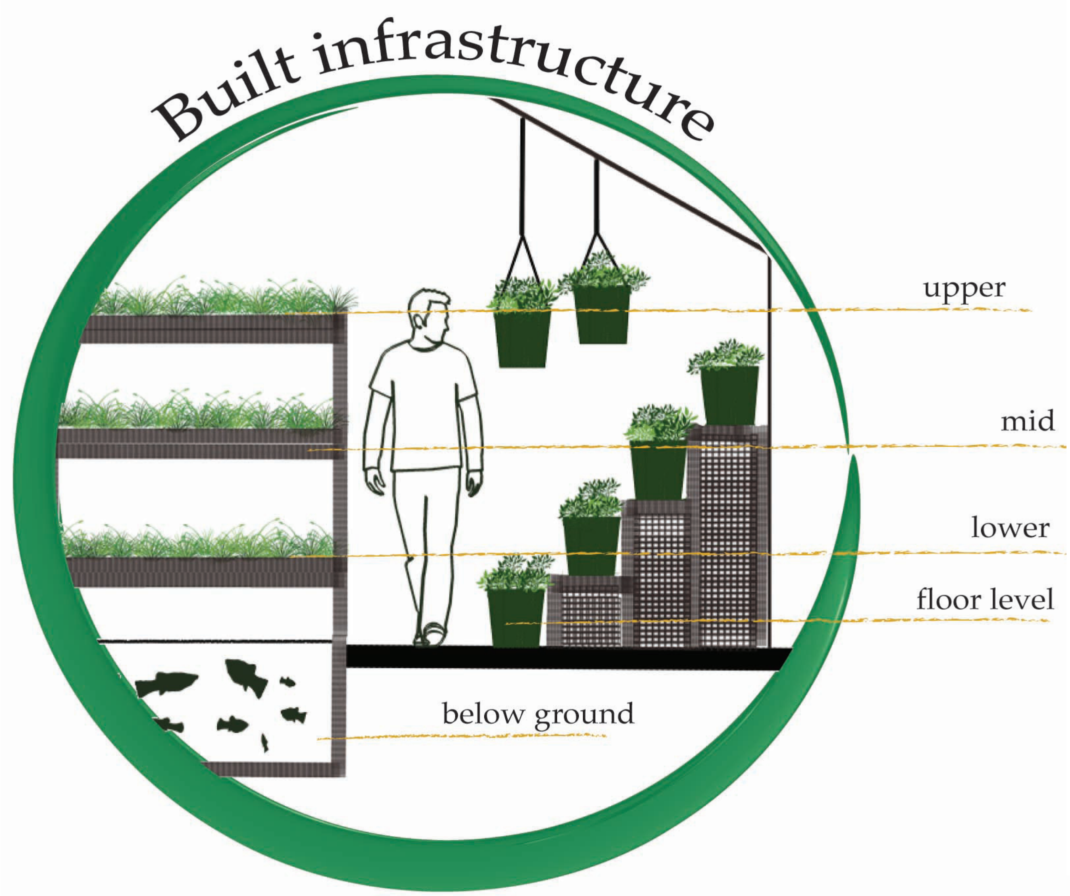
New fish tank being installed for an additional layer of productivity below floor level
Photo by Ryan Harb

Chives and oregano help create an herbaceous understory layer beneath the asian pear tree canopy
Photo by Eric Toensmeier

The Holyoke Forest Garden achieves structural diversity through the intrinsic architectural form and habit of plants. It emulates the architecture of a forest by using plants to delineate ground layer, understory, and canopy layers. Even the root zone is made viable and productive in the forest garden through the use of root-producing crops. Vegetated architecture is a great alternative to built infrastructure where farmers have expertise in edible plants and planting design, and an infrastructurally light farm system is desired. Drawbacks involve being more limited to the constraints of the site, including soil quality, climate, solar orientation, etc. And while resources are saved by not investing in infrastructure, productivity is limited to the maximum number of layers achievable through vegetated architecture.

The case studies' demonstrate different design approaches for structural diversity. The key lesson is that designing productive vertical layers and integrating a range of organisms and species based on their intrinsic adaptations can overcome the problem of limited space. This can be accomplished through the use of built infrastructure or vegetated architecture. Effective structural diversity both maximizes and diversifies productive area, resulting in abundant and complimentary yields. For example, Growing Power's aquaponics system produces fish, sprouts and salad greens, while a plant guild in the Forest Garden produces Jerusalem artichokes, wild leeks and pears. Structural diversity also lends itself to advantageous system dynamics such as the renewal of water and fertility, which will be discussed next.

Finally, both farm systems show how organisms and species and structural diversity must be designed in unison, accommodating each other for maximum productivity and sustainability of the system.



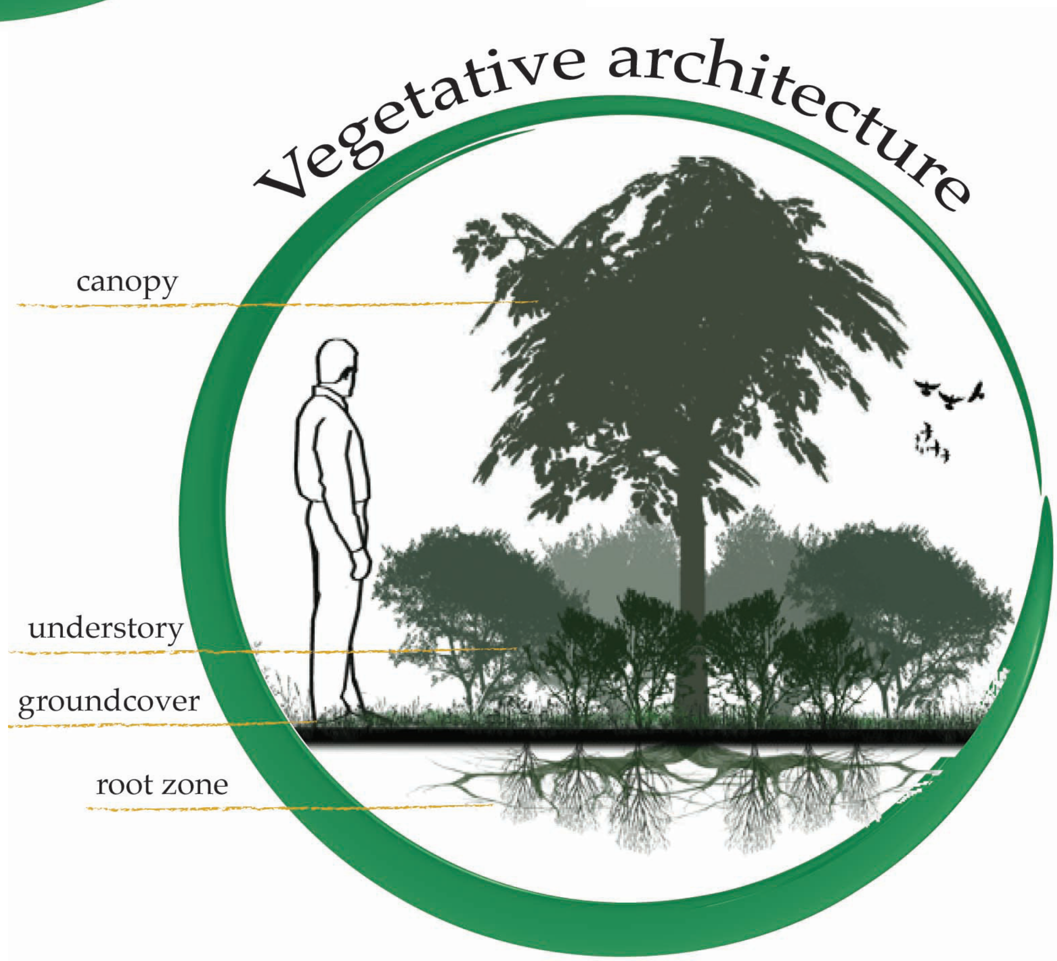


Figure 4 - 2 Comparison of structural diversity
The forest garden uses plants' intrinsic form whereas Growing Power uses infrastructure to create multiple productive vertical layers. Both satisfy criteria: to produce abundant, complementary yields, value and integrate diversity, and turn problems into solutions.

Different kinds of greens can be grown: some in pots and some, like watercress, in the open tray of water
Photos by Ryan Harb

Nutrient rich water is piped up from the tank and run across beds of greens before returning to the tank
Photo by Ryan Harb

System dynamics

Comparative analysis and assessment of the case studies' system dynamics will focus on soil fertility, which includes self-renewing fertility, regeneration and erosion. Soil fertility is selected because it is an intrinsic aspect of system dynamics and absolutely fundamental to sustainable farm systems. Self-renewing fertility and regeneration are the principal components of soil fertility involving the system's ability to generate and maintain its own wealth. They have been identified by current literature as defining features of regenerative agriculture making them pivotal indicators in the urgently called-for transition from conventional to regenerative agriculture (Hellwinckle, et al). Erosion is a major factor in the urban landscape and especially relevant to urban farm systems where stormwater can either be a tremendous resource or a serious liability depending on how it is managed.

The labor input from input:output ratio will also be analyzed and assessed. Labor is an important metric of sustainable farm systems that results, directly or indirectly, from farm system design (as previously discussed in System Design: Organisms and Species). A farm system's need for this critical input must be suited by its availability and affordability within the socio-economic context, and vice versa, urban farm systems can offer substantial socio-economic benefit to their communities by providing jobs and income. With regard to labor, the case studies contrast again, exemplifying how different designs and practices can meet the same farm system criteria within disparate contexts.

Self-renewing fertility

Growing Power's best example of self-renewing fertility is its aquaponics system, which uses water, rather than soil, as a growing medium. Aquaponics is the combination of raising fish in tanks (aquaculture) while growing crops in water (hydroponics). The water from the tanks, enriched by fish waste, is pumped through gravel filtration and then into the trays of leafy plants such as watercress, lettuce and spring greens (a variety of crops can be used). Eventually, the water re-enters the fish tank de-nutrified, and the cycle continues.

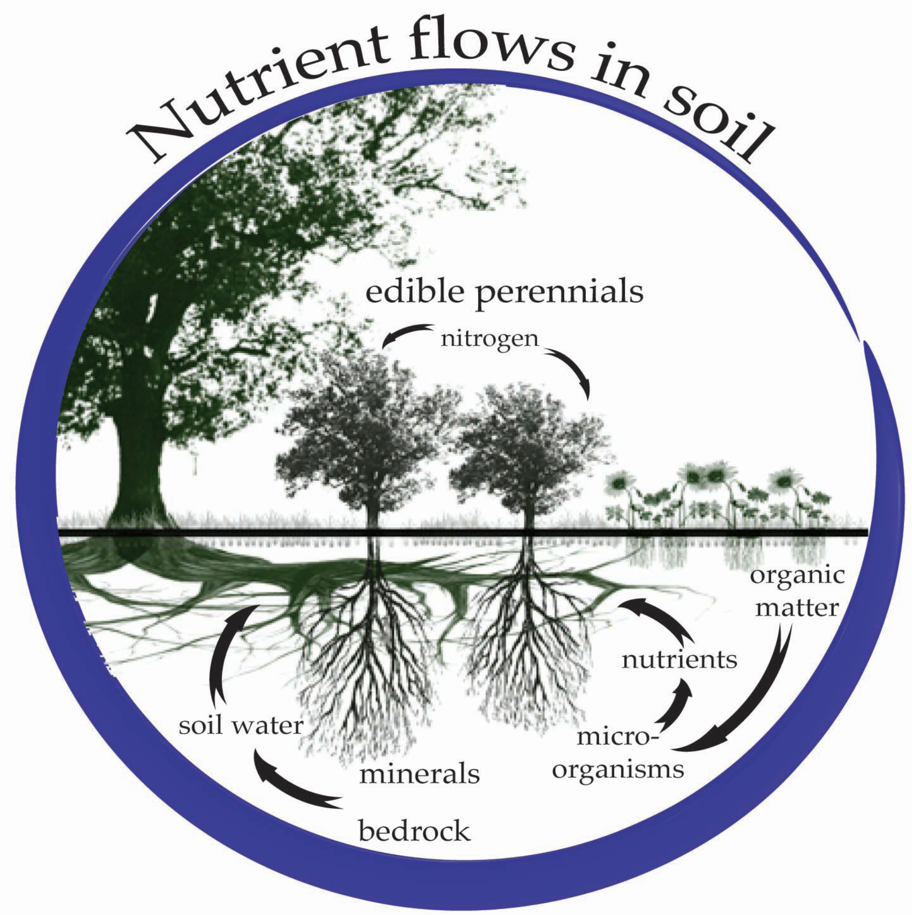
Aquaponics represents a near closed-looped system that, once constructed, renews its own fertility. One shortcoming is that a portion of the fish food comes from outside of the farm system in the form of manufactured pellets. The fish are also fed with worms and sprouts produced on site, suggesting that it may be possible to supply 100% of the aquaponics' fertility in conjunction with other modes of production such as vermiculture and sprouting. Growing Power's aquaponics is a good example of a water-based production system that renews its own fertility.

Having started out with extremely poor soil, the Holyoke Edible Forest Garden is on a positive trend toward 100% self-renewing fertility. This trend was developed through major soil amelioration efforts during the original site preparation, followed by continual regenerative practices. And once established, plants work as natural catalysts of soil fertility. Through beneficial relationships with soil microorganisms, perennial plants automatically gather and store nutrients (Jacke, Volume 2). Nitrogen fixers draw nitrogen from the air and fix it into the soil, while dynamic accumulators draw soil nutrients up from the subsoil and bedrock. As plant architecture is delineated to take advantage of resource availability above ground, so below: rather than compete, the roots of the plant community occupy complementary soil horizons and mutually benefit from each others' role in soil fertility. In this way, self-renewing fertility is facilitated by structural diversity.

The key lessons in this case are, that self-renewing fertility can be accomplished in soil or water given a design that successfully enacts the anatomy of self-renewing fertility. If 100% self-renewing fertility is not immediately possible, farm systems can at least establish a positive trend working towards it as an essential, long-term goal. As seen in both cases, structural diversity plays a critical role in self-

Site prep for perennials requires major upfront effort, but pays off with less long term maintenance
Photo by Eric Toensmeier

Cardboard mulching - a permaculture trademark - helps remediate poor soil and activate self-renewing fertility
Photo by Eric Toensmeier



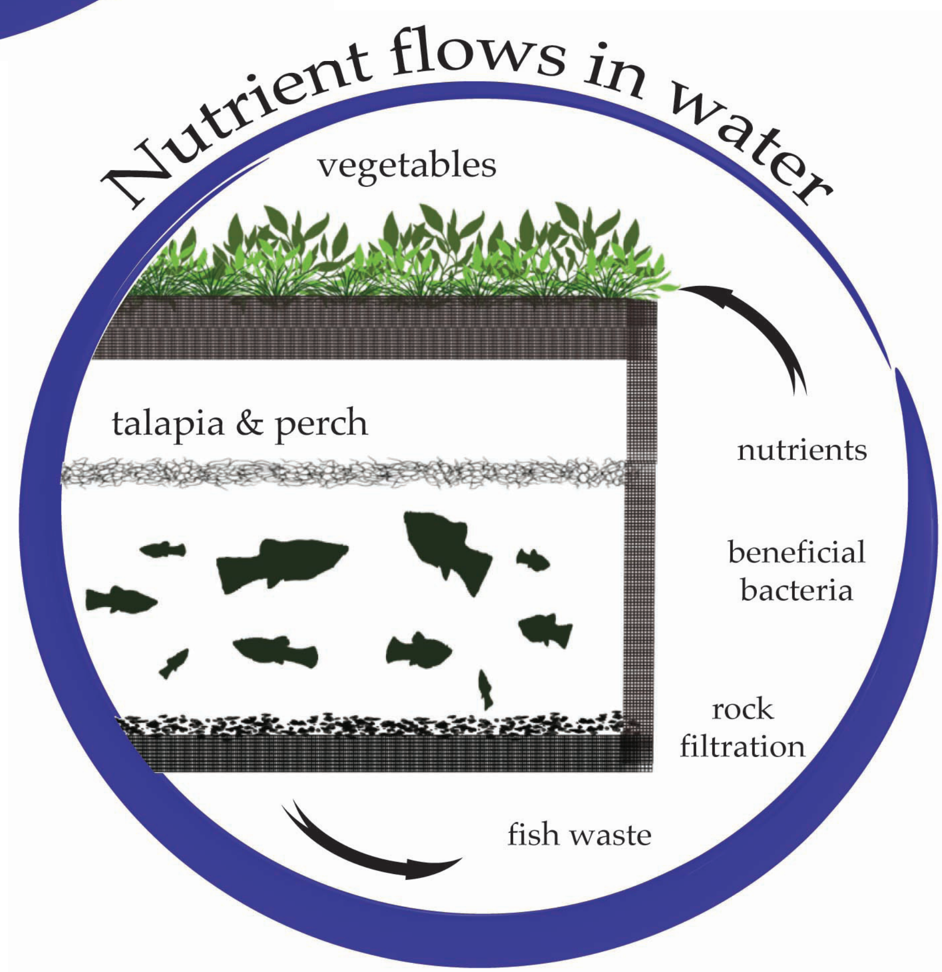


Figure 4 - 3 Comparison of self-renewing fertility
Plants in the forest garden are natural catalysts of soil fertility and work toward increasing nutrient-generation within the system. Aquaponics uses nutrients produced by fish to grow vegetables. Both satisfy the criteria: to renew fertility within the farm system

renewing fertility by making it possible to integrate a variety of different organisms in mutually beneficial relationship to each other, thereby making it easier to renew and sustain fertility.

Regeneration

Growing Power produces an outstanding 100,000 pounds of processed organic matter every four months with its robust compost operation. Wood chips donated by the city, as well as cardboard, leaves, grass clippings, eggshells, hay, animal bedding, manure and food waste from on site go into Growing Power's colossal compost piles. Through partnerships with supermarkets, food and beverage manufacturers, restaurants and cafes throughout Milwaukee, Growing Power collects an additional 80,000 pounds of food waste, 20,000 pounds of brewery waste, 300 pounds of coffee grounds, and 500 pounds of newspaper every week. This equates to 100,800 pounds of waste diverted from landfill and significant cost savings for businesses.

"The mother" is a giant compost pile where all of the urban food waste gets dumped and processed
Photo by Ryan Harb

In exchange for collecting used beer mash from the local brewery - a service that saves the company $3,000/month in waste disposal - Growing Power receives employee discounts, free beer during events, and free retail space at the brewery for selling worm casting. This kind of agreement is called mutual aid. It is an informal economic benefit and an example of diverse economic practices.

Compensating for the significant labor and trucking costs are the multiple yields and benefits of Growing Power's compost operation. Compost, worms, and worm castings are additional, marketable products that generate capital on top of their function as critical, subsistence inputs. These key ingredients are used in every soil-based mode of production at Growing Power, but they are also sold from Growing Power's storefront and website. Even the heat generated as a by-product of decomposition is captured to warm the hoop houses in winter. The labor-intensive processes of constantly building, turning and moving compost piles provide education and employment opportunities.

Students learn about composting with worms and the value of worms and castings as agricultural products
Photo by Ryan Harb

In the forest garden, regeneration happens in place with continual, uninterrupted cycles of growth and decay
Photo by Eric Toensmeier

Finally, Growing Power's compost operation ostensibly extends the farm system boundary to include the city-at-large. Diverting food waste from the urban waste stream while regenerating organic matter through composting reduces the city's ecological footprint because it facilitates waste absorption and resource production within the urban boundary. It is important to acknowledge, however, that the incredible benefits and success of urban composting are based on the excesses (and in turn, the wastes) of modern, global food systems. The vast majority of Growing Power's six million pounds of organic matter originates outside of Milwaukee in farm systems elsewhere on the planet. Once harvested, food is shipped internationally to markets where byproducts and excesses will never return to their place of origin. While it is preferable to capture and store this valuable organic matter rather than waste it, it is important to understand that farm systems elsewhere are being deprived of their own regeneration.

In the Holyoke Edible Forest Garden, regenerating organic matter is mostly automatic and carried out in place by the plants, animals and microorganisms. The forest garden relies on the annual shedding and decomposition of plant foliage, droppings from the chickens, and the excreta of soil organisms such as earthworms to continually renew the supply of organic matter. Following with the Forest Garden's precept of low-maintenance, these processes of regeneration based on the intrinsic behaviors of organisms in relation to each other require no additional effort from the farmer. And yet, compost is generated from the household's food waste, straw from the chicken coop and yard waste. This is added to the garden either as topdressing or an amendment when the soil is being turned over. These simple methods regenerate sufficient organic matter for the forest garden, which already benefits from a high degree of self-renewing fertility. As a result, organic matter from outside of the farm system is not required to sustain soil health.

The key lessons are that organic matter can be regenerated at farm scale and city scale, by creating low-maintenance, ecological relationships or by collecting and processing the wastes of the market economy. Either approach catalyzes ecological, economic and social benefits locally and globally. City scale composting is a logical responsibility for urban farm systems to take on and manage. It is socially and ecologically beneficial as well as economically viable. Composting is a labor-intensive process that creates jobs, yields several marketable products, forges social and economic partnerships, and improves overall urban resiliency by helping the city absorb its wastes and produce resources. Urban composting is an appropriate response to the excesses of the global, industrial food system because it transforms waste into wealth. However, while urban composting is preferable to waste, it still relies on the fundamentally unsustainable practices of industrial agriculture and the global food system.

By contrast, forest gardening is a system in which the work of regeneration occurs within system, automatically and perpetually. It optimally demonstrates self-sufficient soil fertility, neither changing nor relying on the excesses of the global food system.

As outlined and discussed, each farm systems' distinctive methods for achieving self-renewing fertility and soil regeneration are worthy of further recognition and advancement as accepted practice for urban agriculture. They satisfy criteria identified in the literature (Hellwinckle, et al) by enacting regenerative practices in the urban environment. As such, they serve as compelling examples of urban agriculture's role in the larger movement to transition toward regenerative agriculture.

Erosion

The erosion issue is worthy of discussion because the stormwater in cities can be extreme and require significant management and infrastructure. Depending on how it is handled, urban stormwater can serve as a valuable natural resource and farm input, or potentially undermine soil fertility and farm system viability while polluting nearby waterbodies

The new outdoor aquaponics tank will use rainwater collected from the rooftops of the greenhouses
Photo by Ryan Harb

The pond in the forest garden collects and stores rainwater from the roof of the house
Photo by Jonathan Bates

with topsoil runoff. This system dynamic is a direct result of design decisions regarding the use of buildings and infrastructure, as well as the nature of site preparation.

Both Growing Power and the Holyoke Edible Forest Garden have installed catchment systems, which collect and store rainwater on site. In Holyoke, water is collected from the roof of the house, and at Growing Power, from the greenhouse roofs. Rainwater is mostly used for irrigating crops, however both farm systems have integrated their rainwater harvesting with aquaculture that allows them to cultivate fish and water-born plants. In both cases, the problem of stormwater on impervious surfaces has been turned into a solution whereby rooftops and infrastructure deliver water; a most critical resource.

Comparing the rest of the site, however, reveals significant contrasts with regard to stormwater, permeability and the threat of erosion. While this metric was not scientifically measured, deductive observation makes it possible to infer the significance of erosion in each case. The Holyoke Edible Forest Garden was designed to have a high ratio of extremely permeable areas to compacted areas. It had sandy soil conditions to start, and extensive soil amelioration was completed during site preparation to increase permeability and moisture-holding capacity in the soil. They continually maintain and enhance permeability and moisture-holding capacity with practices such as double digging, mulching, and cover cropping. As a result, the Forest Garden produces low to no erosion from runoff.

By contrast, Growing Power is a highly impervious, highly compacted site covered by buildings, greenhouses, hoop houses and widespread pedestrian and vehicular pathways. The intensive infrastructure and soil compaction throughout the site make it extremely vulnerable to stormwater runoff, which could erode the farm's compost and topsoil and cause sedimentation in the stream adjacent to the property.

The key lesson regarding erosion is that the soil conditions that foster dense plantings of deep-rooted perennials also resist erosion because permeability and moisture-holding capacity are maximized while perennial plants do not require tilling and help hold soil in place with their roots. Also, minimizing the total surface area of roads and pathways and maximizing the permeability of those surfaces is an important design strategy for preventing stormwater runoff.

Labor

The labor required at Growing Power to keep the system functioning is immense. In part, this is due to its size, its robust agenda, and its far-reaching applications socially, economically and ecologically. And as described earlier, the need for labor is also a consequence of design decisions. Up-front investment in site preparation and design was limited, and production was started at almost immediately, in part because people wanted work!

However, the bulk of daily tasks at Growing Power involve continually cycling farm system inputs and outputs within, on to and off of the site. Other tasks include prepping planting areas, mixing different kinds of growing mediums, seeding, planting, watering, feeding, cleaning, covering, uncovering, and harvesting. The multiple, productive systems are only kept healthy and productive by means of extensive and intensive human labor. This could be seen as a design flaw, whereby the entire system would completely fall apart without high labor input. But in this particular context, the need for labor alleviates the problem of unemployment in the neighborhood and provides educational opportunities for students and interns. Growing Power continues to teach and employ more and more people as their operation and programming continues to expand.

Taking care of all the animals is a lot of work
Photo by Ryan Harb

There is a constant need to haul compost
Photo by Ryan Harb

Long rows of winter greens must get covered and uncovered daily
Photo by Ryan Harb

Once the forest garden gets established, most of the labor involves foraging for the bounty
Photo by Eric Toensmeier

Harvesting fruits off of the trees
Photo by Eric Toensmeier

By contrast, the Holyoke Forest Garden is extremely low maintenance, and the residents themselves can accomplish the required labor. In fact, each resident has time to dedicate to other jobs and careers outside of maintaining the forest garden. This dynamic is the result of a carefully designed farm system that maximizes its intrinsic ability to achieve productivity, stability and resilience without intervention by human hand. Design elements such as structural diversity and organisms and species, are used to increase the amount of functional interconnection within the farm system. In other words, the forest garden is based on relationships between design elements in which needs are met and yields are generated automatically, so the labor of operating the farm system is in the system's own hands. The drawbacks of this approach are that forest garden design requires expertise, installation requires labor and capital up-front, and agricultural yields increase slowly over time as plantings mature. But the long-term payoff is a high-yielding farm system that requires a fraction of the standard day-to-day maintenance.

The labor metric is another important point of contrast between the case studies revealed by applying the assessment method. They represent near-opposite strategies for managing this farm system dynamic, each suiting its context brilliantly. One key lesson is that interconnection vs. discreteness between modes of production is a critical design consideration for accomplishing extremes of labor-intensiveness. Also, the amount of design, planning and site preparation up front can be a determining factor of labor over the long term.

Outcomes and Benefits
Agricultural yield

One might say that this aspect of the analysis and assessment is like comparing "apples to oranges". And one would be right! The varieties and volumes of produce achieved by these divergent farm systems warrants comparison because they are important outcomes affecting each farm system's overall viability. Both Growing Power and Holyoke's Edible

Forest Garden serve as contrasting examples of how productive plants and animals must be holistically incorporated as elements of a design so as to produce particular kinds and volumes of agricultural yields while satisfying given constraints such as site conditions, budget, available labor and so forth.

Compost is definitely one of the most important agricultural yields at Growing Power
Photo: http://www.growingpower.org/growing.htm

Growing Power's emphasis on livestock is a design characteristic that resembles a traditional family farm. Its substantial workforce meets the care and maintenance requirements for the animals, and the refuse of local supermarkets and bakeries largely satisfies the feed input (although feed is also imported). The dynamic between food service establishments and livestock, which Growing Power puts into place, enacts an important permaculture principle: one's wastes are another's resource. This achieves the ecological benefit of diverting significant food waste from the urban waste stream. It also improves the input:output ratio by minimizing the expense of manufactured feed. In return, the animals yield meats such as chicken and fish, and eggs from the hens and ducks. By keeping bees on the property, Growing Power boosts pollination of its vegetable crops as well as local biodiversity. Honey, a high-value product, is harvested from the beehives on site. Annual vegetables are produced to the extents allowed by climate, while huge quantities of fresh salad greens, herbs and sprouts provide nutrient-dense vegetables year-round.

The compost and vermiculture operations produce three yields: compost, red wrigglers (specific type of worm for compost), and worm castings. All three are marketable products and major subsistence inputs, while serving the ecological benefits described previously.

June fruit harvest in the forest garden can include many kinds of berries including these red and white currants
Photo by Eric Toensmeier

The Holyoke Edible Forest Garden yields a stunning variety of fruits and vegetables. The biodiversity intrinsic to the forest garden's design, consisting of more than 200 cultivated plant species, produces an abundant diversity of complementary fruits and vegetables for up to 6 months of the year. Laying hens provide eggs throughout the year, and honey is harvested from the forest garden's beehives.

Perennial kale called 'sea kale' grows thick and abundant, year after year
Photo by Eric Toensmeier

Winter greens are harvested and replanted multiple times in a year at Growing Power
Photo by Ryan Harb

A farm system based on perennials, the forest garden has the advantage of having a renewable and increasing supply of nursery stock. As the plants of the forest become established and their growth becomes vigorous, their maintenance requires occasional digging up and cutting back; activities which serve the dual purpose of harvesting nursery stock. Over the years, the Holyoke Edible Forest Garden has developed a substantial yield of perennial plant stock contributing to the farm system's overall yield and viability.

In the end, both farm systems produce abundant agricultural yields of complementary items; meats and vegetables, eggs and honey, compost and worm castings, etc. Growing Power's products are destined for sale, CSA distribution and subsistence, while the Forest Garden uses its goods mostly for subsistence, again showing different applications of plants and animals to appropriately suit their different contexts. The key lesson is that production must be possible within the farm system's means and produce a yield that is satisfactory in terms of quantity, variety and intended purpose (eg. market, subsistence).

Economic benefits

One of the most exciting areas of difference between the case studies is in their economic outcomes and benefits. Their underlying socio-economic structures, goals and objectives follow completely divergent paths. Operating as a commercial enterprise, a non-profit and a landtrust, Growing Power uses multiple economic models to accomplish the outstanding goals - such as reducing childhood diabetes by increasing access to local food - that have earned it nation-wide recognition. In addition to commercial sales via its store and website, Growing Power markets and distributes its produce in "farm baskets". The community-supported-agriculture style farm baskets are available in a range of sizes based on family size and dietary need. There is also a pay-as-you-go option in which community members on low-income budgets can access a share without having to pay the annual cost up front.

As a non-profit, Growing Power is able to receive grants that sponsor its education and infrastructure facilities. These formal, economic modes are well suited for Growing Power's outstanding means for enterprise development, capital generation, and job creation. They reinforce farm system activities and align well with its goals and objectives.

By contrast, the Holyoke Edible Forest Garden lends itself more to informal economic outcomes; household savings being the most significant. The amount of food yielded by the forest garden provides the four residents their fruit and vegetable needs for 4-6 months of the year. This constitutes substantial savings based on current retail prices for produce, not to mention that many or most of the crops are not available in supermarkets at all. The informal economy supports the Holyoke Edible Forest Garden's focus on producing a diversity of crops, rather than producing as much as possible of a single crop, as in a monoculture. Surpluses then become valuable for use in barter and trade.

As with Growing Power, the economic outcomes are well suited to support the underlying premise and activities of the farm system and align with its goals and objectives. Their divergent economic strategies are noteworthy examples of economic practices that dovetail with farm system design and dynamics as well as goals and objectives to demonstrate sustainability in terms of economy and community, as well as ecology.

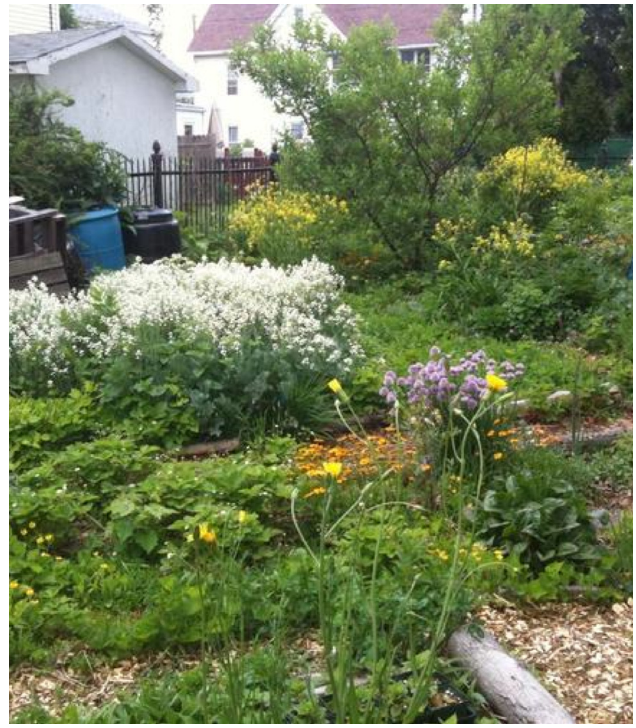
Ecological benefits

Discussed earlier, Growing Power's waste recycling and composting operation is immense and one of its greatest ecological benefits. The remarkable ability to recycle waste and regenerate organic matter within the city is beneficial both locally and globally, while another major ecological benefit is the reduction of food miles for the diets of the many Milwaukee residents served by Growing Power. While both of these metrics are difficult to measure accurately, they are worthy of further investigation and validation. Waste recycling and regeneration of organic matter

Figure 4 - 4 Transforming waste into wealth
Growing Power's compost operation diverts 6 million pounds. of waste from landfill annually, creates jobs, generates capital, and results in major cost savings. Urban composting turns problems into solutions, regenerates organic matter, and fosters formal and informal economy

photo: http:www.growingpower.org/compost.htm help to restore beneficial flow of resources within the urban boundary, whereby the city can absorb some of its own wastes and produce some of its own needs, reducing the need to import resources and export wastes. This effectively reduces the city's ecological footprint.

The Holyoke Edible Forest Garden also recycles urban waste and reduces food miles, but on a much smaller scale. The most tremendous ecological benefit of the forest garden is its ability to foster air, soil and water quality for the urban environment while providing valuable wildlife habitat. The soil is remediated and enlivened by the forest garden's development. Water is captured, cleaned and infiltrated into the earth, and the dense vegetation cools, cleans and restores oxygen to the air. At the same time, informal monitoring by the residents has accounted for significant increases in wild pollinators and urban wildlife within the garden, including specialized species such as salamander.



The forest garden's abundant flowers in May provide abundant food source for wildlife and pollinators
Photo by Eric Toensmeier

Naturally, by designing a landscape that mimics a forest ecosystem, the forest garden fosters wildlife populations and biodiversity by providing much-needed habitat. By creating and enhancing the experience of nature in the city, the forest garden also contributes to quality of life and sustainable human habitat within the city.

As with the economic benefits, the case studies' different ecological benefits are exemplary of the range of possibilities and the potential for any farm system to produce valuable, customized outcomes and benefits.

Social benefits

Both case studies feature education as a major social benefit. Growing Power's extensive educational programming includes youth development, community engagement, and technical assistance, as well as training in farm system management and creating community food systems. Its multiple modes of production requiring constant maintenance provide ample opportunity for education through hands-on experience. Growing Power accepts full-time interns

Flower feeding pollinators
Photo by Eric Toensmeier

Growing Power's ample programming has led it to preeminence in sustainable urban agriculture education
Photo by Ryan Harb

Getting ready to share a meal among students, staff and interns in Growing Power's main greenhouse
Photo by Ryan Harb

year round, facilitates volunteers every weekend, gives daily tours, and periodically offers formal workshops and training sessions. Growing Power's philosophy is that farming should be accessible to all people and replicable in every neighborhood. The range in educational programming is such that people of all ages and incomes may participate and gain access to the knowledge and skills being practiced and improved, using the farm as an educational lab.

Within the past 5 years, over 1,000 students have visited the Holyoke Edible Forest Garden to learn permaculture and forest gardening practices by participating in workshops facilitated by Eric, Jonathan and other instructors. Neighbors and passers-by occasionally show up for impromptu orientations. As a main focus of the Apios Institute, the Holyoke Edible Forest Garden provides a source for detailed analysis of the forest garden's design.

Both farm systems serve as laboratories for their proprietors. They offer a space containing a huge range of projects for people to come and engage with, to learn, to experiment, and to continue developing the skills and knowledge involved in urban agriculture. It is a mutually beneficial relationship in which visitors gain experience and know-how, while the farm gains laborers, publicity and sometimes, additional capital. While the two approaches to education are, like everything else, extremely different in comparison, they meet each farm systems' individual mission statement to be centers for demonstrating, developing and disseminating the knowledge and skills particular to their agricultural style or urban landscape typology.

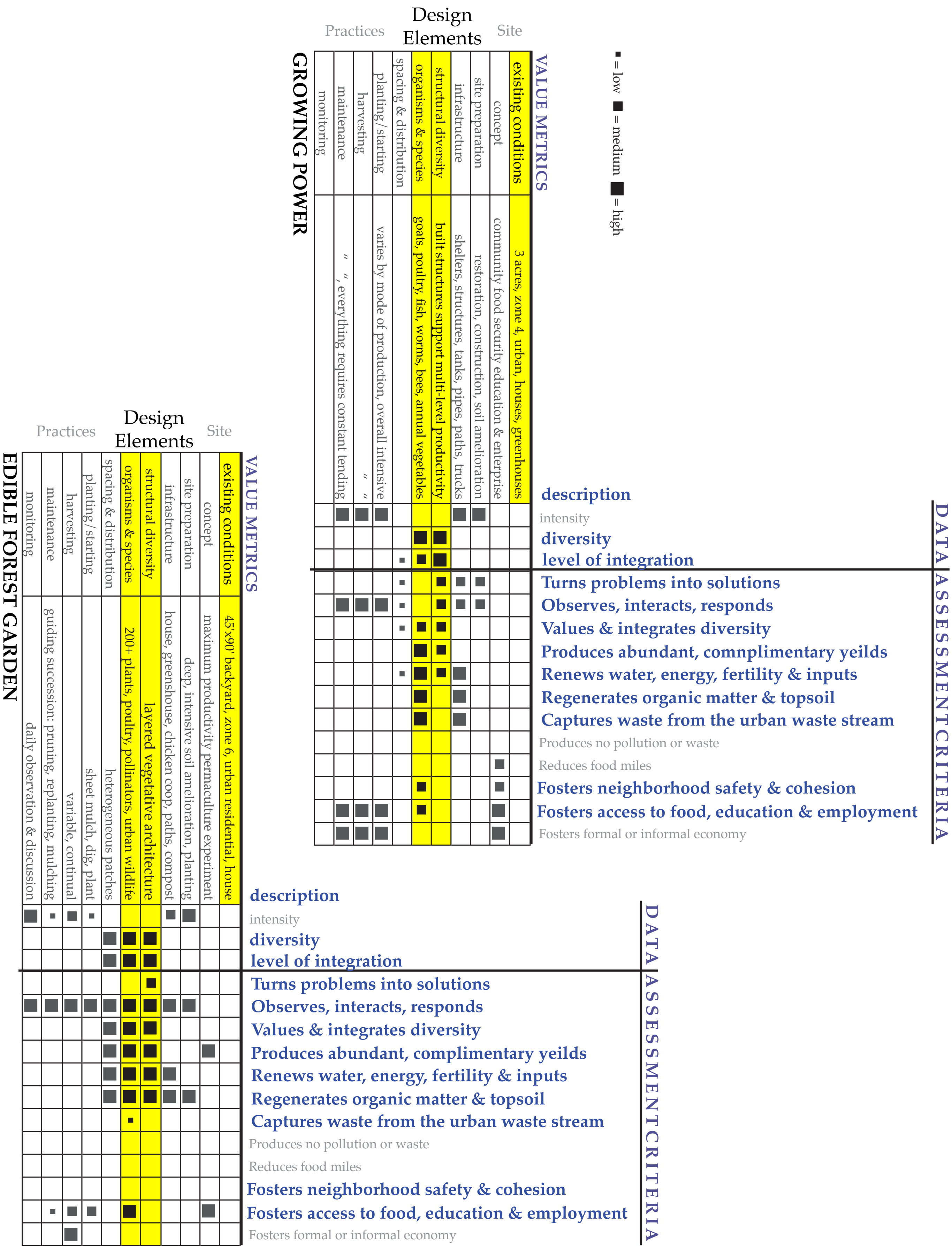


Figure 4 - 5 System design matrices and foci of comparative analysis and assessment

□ = zero ▪ = low ◼ = medium ■ = high

Y = yes N = no

⚐ = red flag

VALUE METRICS

DATA ASSESSMENT CRITERIA

		description	yes/no	usage	cost	output	percentage of crop	Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
Water	source	municipal & rainwater		◼					◼			◼							
Energy	fossil fuel	natural gas, diesel, electricity	Y	◼											⚐				
Energy	renewable fuel	human, passive solar, compost heat	Y	◼	▪							◼			◼				
Soil fertility	**self-renewing fertility**	**aquaponics renews fertility for plants, but not fish**	N									◼							
Soil fertility	erosion	high impervious surfaces, rainwater catchment	Y			▪									⚐				
Soil fertility	**regeneration**	**compost, worm castings & manure**	Y			■		■				■	■	■					
Plant health	survival rate	90%					◼				◼							◼	◼
Plant health	pest damage						▪				◼								
Input:Output ratio	raw materials	compost, seed, coir, animals, feed, hay, wood, pots, etc		◼	◼						◼	◼		◼			◼		◼
Input:Output ratio	land	3 acres urban agricultural																	
Input:Output ratio	tools & machinery	standard hand tools, mechanical sifter		◼	▪														
Input:Output ratio	**labor**	significant volunteer labor ameliorates cost		■	◼			■	■		■	■					■	■	■
Input:Output ratio	productivity	cultivated area x $ / square foot				◼					◼					◼		◼	◼
Input:Output ratio	pollution	carbon emissions, agricultural odor & runoff				◼									⚐		⚐		
Input:Output ratio	waste																		

GROWING POWER

DATA ASSESSMENT CRITERIA

		description	yes/no	usage	cost	output	percent of crop	Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
Water	source	municipal & rainwater		◼				◼				◼							
Energy	fossil fuel	negligible electric	N	□											◼				
Energy	renewable fuel	human, passive solar	Y	◼	□							◼			◼				
Soil fertility	**self-renewing fertility**	**positive trajectory, via nitrogen fixers & perennials**	N									◼							
Soil fertility	erosion	high soil permeability, organic matter & H2O uptake, and rainwater catchment	N			□									◼				
Soil fertility	**regeneration**	**high organic matter: mulch, compost, manure**	Y			■		■				■	■	◼					
Plant health	survival rate	90-93%					◼				◼							◼	◼
Plant health	pest damage	5-8%	Y				▪				◼								
Input:Output ratio	raw materials	plants, seed, mulch, wood, compost, pots, etc.		◼	▪						◼	◼		◼			◼		
Input:Output ratio	land				◼														
Input:Output ratio	tools & machinery	stand hand tools		◼	▪														
Input:Output ratio	**labor**	mostly self, some volunteer		▪	□												▪	▪	■
Input:Output ratio	productivity	cultivated area x $ / square foot				◼					◼					◼		◼	◼
Input:Output ratio	pollution		N												◼				
Input:Output ratio	waste		N												◼				

EDIBLE FOREST GARDEN

Figure 4 - 6 System dynamics matrices and foci of comparative analysis and assessment

▪ = low ■ = medium ⬛ = high

= increase = decrease

Y = yes N = no

DATA | ASSESSMENTCRITERIA

VALUE METRICS

			description	yes/no	increase/decrease	annual total	annual cost savings	Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
	typology	multi-modal urban farm & education center																	
Economic benfits	enterprise development	expansion of marketed goods & services		Y		■			■								■	■	■
	investment opportunities	capital increase		Y		■			■								■	■	■
	household savings																		
	job creation	40 employees		Y		■		■	■								■	■	■
	diverse economy																		
Ecological benefits	waste recycling	6 million pounds organic waste per year		Y		■	■	■			■	■	■	■			■	■	■
	reduced food miles			Y												■			
	air, soil, water quality																		
	biodiversity																		
Social benefits	dietary diversity			Y			■				■							■	
	education	tours, interns, volunteers, students, neighbors		Y		■					■						■	■	■
	quality of life																		
	food security																■	■	
Gross yield	marketed	sprouts, vegetables, fish, poultry, goat, compost, worms		Y		■					■					■		■	■
	nonmarketed	subsistence of farm food needs & some inputs		Y		■	■				■	■			■				■

GROWING POWER

DATA | ASSESSMENTCRITERIA

			description	yes/no	increase/decrease	annual total	annual cost savings	Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
	typology	urban edible forest garden																	
Economic benfits	enterprise development	nursery, writing, teaching		Y		■		■	■								▪	■	■
	investment opportunities			Y		■													■
	household savings	fruit & vegetable needs of 4 adults, 6 mo/year		Y		⬛	⬛		⬛										■
	job creation	nursery, writing, teaching		Y		■		■	■								▪	■	■
	diverse economy	trade, barter, mutual aid, skills/services exchange		Y		⬛					■						▪	■	■
Ecological benefits	waste recycling	domestic & city scale		Y		▪	▪	■				■	■	▪					
	reduced food miles			Y												■			
	air, soil, water quality	no runoff, remediated soil, dense vegetation									▪						▪		
	biodiversity	observable increase in pollinators & wildlife		Y						■	■								
Social benefits	dietary diversity			Y			■			■	■							■	■
	education	tours, interns, volunteers, students, neighbors		Y		■					■						■	■	■
	quality of life	ability to meet basic needs vastly improved									■						▪		
	food security										■							■	
Gross yield	marketed			N															
	nonmarketed	household subsistence & farm system inputs		Y		⬛	⬛				⬛	⬛	⬛			⬛		⬛	⬛

EDIBLE FOREST GARDEN

Figure 4 - 7 Outcome and benefits matrices and foci of comparative analysis and assessment

Conclusion

This research project produced a current, customized assessment method and framework for the evaluation of urban farm systems. The method and framework encompass accepted practices from related disciplines based upon criteria for responding to global issues described in the literature review. In this way, individual farm systems and production practices are linked to broad, contemporary issues such as urban quality of life and ecological sustainability through criteria and metrics that account for their influence. Thus, the various typologies of urban agriculture finally have a much-needed, all-purpose tool for evaluating social, environmental and economic impacts locally and globally, and for verifying/validating its ability to create beneficial and sustainable change in 21st century human ecology.

Through application on two case studies, this project demonstrates how the research method can be used to identify outstanding design strategies that respond to the particulars of context, positively influence system dynamics, and produce desired outcomes and benefits. Comparative analysis and assessment can also show how the process of assessing different farm systems within the same evaluative framework reveals key lessons about the potential for different design strategies to meet similar criteria within disparate contexts. The application shows comparative analysis and assessment as a powerful strategy to distinguish and advance multiple, successful designs and practices within urban agriculture.

Given this capacity, analysis and assessment can be used both as a research method for producing new knowledge as well as a design tool for evaluating existing farm systems or developing new ones. Comprehensive evaluation would reveal strengths and weakness and inform the recommendations for improving or optimizing a farm system's performance. And in the case of developing a new farm system from scratch, the framework and matrices can be used as guides throughout the design process as they represent a comprehensive outline of considerations and offer a roadmap for imagining and testing different design strategies.

DIRECTIONS FOR FUTURE RESEARCH

This paper recommends broad application of the analysis and assessment method to existing urban farm systems. The endeavor would provide a database of critical research and conceptual tools for understanding urban agriculture's many benefits, accurately distinguish production practices, further articulate a new and relevant language, and establish a more overarching understanding of the subject. The research, carried out by academics, urban planners, designers, policymakers and community members, should be integrated in a manner that creates an improved synthesis of knowledge at the national and international level. By introducing a uniform method into investigations, meaningful comparisons and discussions can be made so that research may expand its horizons while responding more effectively to particular urban farm systems.

Analysis and assessment of existing farm systems

Urban farm systems with innovative or distinctive food production systems, as well as major, leading projects should be sought out and evaluated using this papers' methodology. As described in Chapter 3, farm system analysis and assessment looks at all aspects of design, dynamics, outcomes and benefits. Since farm system analysis involves collecting and organizing extensive data, it is helpful to use a survey like the one created for this project (see Appendix), tailored to the new focus and scope. Farm system assessment requires using that data to decide how well the farm system is performing according to the chosen set of criteria and rating system. Evaluating existing projects is the ultimate way to learn from experience and avoid 'reinventing the wheel'. Ultimately, documenting and disseminating the findings, key lessons and best practices discovered through researching existing projects would significantly inform other projects, existing or in development.

Steps for single project evaluation

- Identify the project's mission, including specific goals and objectives.

- Complete analysis using the survey (see Appendix) by recording data in the most meaningful form(s): numbers, figures, descriptive text, illustrations, photographs, etc.
- Pursue missing information and undiscovered key lessons, especially where value metrics are significant, yet traditionally unaccounted for.
- Change and rank the assessment criteria used in the assessment matrices so that they incorporate the farm system's own mission, goals and objectives and/or those of the research project.
- Complete farm system assessment.
- Assess the farm system's greatest advantages and disadvantages.
- Assess the farm system's most significant local and global impacts.
- Determine the best practices and key lessons the farm system has to offer.

Steps for multiple project evaluation

- Seek out two or more case studies with significant contrasting or corresponding characteristics for comparison. In particular, comparative research on various production practices, social/economic structures, and landscape typologies, is currently needed.
- Analyze and assess case studies using the steps listed above.
- Continue to distinguish and define case studies' contrasting characteristics with regard to design, dynamics, and outcomes. Convey those findings using the most appropriate and effective form of information: numeric value, qualitative description, drawing or illustration, indication of increasing/decreasing trend, etc.
- Where case studies' corresponding characteristics consistently perform well (for example, raised beds over asphalt design strategy or various CSA business models), develop a set of best practices that model the successful strategies.
- Where corresponding case studies consistently struggle, determine key lessons, and if possible, develop a trouble-shooting research method aimed at resolving the limitation.

Developing new urban farm systems

From the start, the evaluative framework can be used to delineate decision making for the development of brand new projects. It serves as a comprehensive map of all attributes requiring consideration individually and as part of a whole.

Steps

- Develop a project mission, goals and objectives.
- Conduct site analysis.
- Conduct community capacity survey.
- Develop a business plan.
- Using the evaluative framework as a guide, design the farm system foundation by choosing elements that suit the context and optimize the resources inventoried in the preceding four steps.
- With the new farm system mapped out, test design decisions in relationship to each other and to the whole. For example, crop selection is appropriate for site conditions, requires production practices conducive to the operational plan and produces a favorable yield for the marketing plan.
- Begin implementation.

Additional subjects in need of further inquiry

- Comparative analysis and assessment between small-scale farm systems and industrial scale agri-businesses.
- Investigation of small-scale agriculture's need for greater labor and expertise in proportion to its overall greater productivity.
- Further development of multi-disciplinary scientific methods for generating better, stronger data and strategies for obtaining and funding data collection.
- Further articulation and more accurate distinctions of practices within urban agriculture. Development and strengthening of the language including the definitions of terms like 'food security', 'economic viability', and 'ecologically sound'.
- Investigation of urban farms as capitalist enterprises uncompromising of social and ecological equity.

IMPLICATIONS FOR GLOBAL SUSTAINABILITY

Although urban agriculture is traditional and historic throughout the world, it is experiencing a revival today in altogether new cultural, political, environmental and economic contexts. Faced with a whole new set of issues, the forms and functions of contemporary urban agriculture are rapidly evolving and expanding in order to be more effective and relevant in today's world. Possibly one of the most important objectives for contemporary farm systems is connecting local actions to global implications.

This project establishes that connection by embedding it within the value metrics and assessment criteria of the evaluative method. By design, the evaluative tool makes it possible to analyze the farm system at local scale and subsequently, to rank the findings according to global impact, influence or importance. This additional layer of complexity is herein considered a defining feature of 21st century urban agriculture. Despite the challenge of researching broad, sometimes abstract phenomenon such as those outlined in the literature review, a strong understanding of its global implications is crucial to employing urban agriculture as a vital means for beneficial change, and the demand for better data can provide the impetus for developing stronger scientific methods.

For example, the findings of this project include descriptive assessments of each farm systems' influence on their cities' ecological footprint. Although it is nearly impossible to track such impact precisely, deductive reasoning can infer that both case studies, especially Growing Power, serve to effectively reduce the ecological footprint of their respective city by restoring beneficial resource movement within the urban boundary, whereby the city can absorb some of its own wastes and produce some of its own needs. By advancing the trend of sustainable flow of resources and reducing the need for resource imports and waste exports, the farm systems make decisive contributions to lessening the negative impact of those cities on the planet, at the same time fostering resiliency of the urban environment to withstand shocks or interruptions in resource movement.

Both case studies reap social, economic and ecological benefits impacting sustainable human habitat; by design, and by unintended, positive consequence. Ultimately, both farm systems produce the desired results for their particular contexts, having local and global significance. The abundant production of a variety of fresh foods, economic structures that engage the underserved, increased employment and educational opportunities, increased wildlife habitat and nature in the city, and the occasion for community members to unite around a common cause; these results are also central characteristics of sustainable human habitat. The demonstrated potential for urban farm systems to produce particular outcomes and benefits through deliberate, informed design, suggests that urban agriculture's role in influencing sustainable human habitat can grow both broader and deeper, so that cities may become increasingly socially vibrant, economically viable, and ecologically sound.

The comparison between urban agriculture and conventional, industrial agriculture is a comparison between contrasting cultures, economies, geographies, and more. From their historical origins to their present day aims, they are virtual opposites, and modern media often portrays a relationship loaded with social and political tension. Urban agriculture often serves as a stage for social uprising, environmental activism, and assorted radicalism largely because it is such an effective strategy for resisting conventional agriculture and the modern, globalized economy upon which it rests (Gottlieb, 2002).

But rather than simply echo the politics or dogma surrounding agriculture, this project emphasizes the importance of objective assessment within a current, comprehensive framework. A multi-disciplinary, scientific platform that allows for the analysis and assessment of virtually all farm systems within a common framework can help overcome political and/or professional divisions. With the fundamental, shared elements of farm systems mapped, investigations may target a diversity of agricultural styles for analysis and assessment;

comparing design, dynamics, outcome and benefits as nonpartisan constituents in the subject of food production. By distilling the subject in this way, perceived barriers within the discourse may be surmounted, and agriculture may be revitalized, optimized, and sustained, in response to present day challenges, through objective inquiry, assessment and transformation.

For example, comparative analysis and assessment found that both case studies, through very different means, produce in abundance, regenerate organic matter, renew fertility, and reduce food miles. These characteristics are especially significant given the quandary of conventional agriculture as outlined in current literature (Hellwinckel, et al., 2009, Heinberg, et al., 2009). In this way, the evaluative method again implicates urban agriculture in a global issue, showing two examples that actualize sustainable, regenerative practices and restore viability and productivity in agriculture.

Finally, because the subject of urban agriculture in the 21st century is relatively new, growing and changing rapidly, it is important that discourse implement new and appropriate language to accurately describe it. This project has introduced a new glossary of useful terminology (see Appendix) as a contribution to the discourse. Additionally, the evaluative framework offers a foundation upon which future research can build as it articulates and distinguishes new meanings through continued research and discovery.

OBSTACLES AND OPPORTUNITIES

The most obvious obstacle encountered in this project relates to its delimitations outside of the heavily investigated socio-economic dimensions of urban agriculture and outside of traditional scholarly spheres. There is a lack of good data, especially for the unconventional and broad scale metrics that are difficult to measure or involve specialized assessment methods (eg. biodiversity, food miles, ecological footprint). The tasks of generating and managing data for the purposes of validation, accounting and inquiry are not likely to be feasible for farmers to accomplish themselves due to time, money or personnel constraints. While urban agriculture is generally understood as having a wide range of outcomes and benefits, that understanding will remain nebulous and vulnerable to invalidation without precise, empirical evidence with which to make its case. Strong data is also critical to the production and proliferation of new skills and knowledge in the field.

While urban agriculture is enjoying a surge in popularity in the practical world, it exists in a relative no-man's land academically. Lacking a traditional academic discipline within which it squarely fits, it is only tangentially associated with standard subjects. Most educational institutions offering liberal arts education don't teach urban agriculture, even at the graduate level. For the most part, university faculty members are unfamiliar with the subject and unlikely to be researching it. Given the importance of research to the advancement of a subject, and the importance of academic acceptance (and funding) to research, urban agriculture stands at a disadvantage without representation in higher education, and this is an important obstacle to overcome.

The professional world is similar, in that urban agriculture is still a relatively marginal and under populated field compared to mainstream occupations. In the U.S., community gardens are the more common form of urban agriculture and tend to be focused on informal economic practices such as subsistence, barter, and trade, whereas entrepreneurial farm systems (such as Growing Power) operating as a cohesive enterprise in the market economy are uncommon. Professionals with related skills, such as landscape architects, designers, contractors, consultants, and the like, may get the occasional project but would be hard-pressed to focus exclusively on urban agriculture full time. Furthermore, farmers will often opt to do the work of such professionals themselves, wherever possible.

Employment for urban agriculture is stronger in the public sector where non-profits and government agencies implement urban agriculture as a means for social and economic development. But with the mainstream market distorted to favor industrial agriculture and contemporary consumer culture ill-equipped to genuinely value social, ecological or informal economic benefits, it will be difficult for urban agriculture to stake a claim in the market economy and earn recognition as a viable occupation. Until socio-economic values shift forcing institutional policy and economic markets to embrace alternatives, urban agriculture will face the prejudices of conventional economic ideology and deal with exclusion from formal markets as an obstacle to its growth and development.

The hegemonic thinking in which maximum productivity and economies of scale are the central focus of agriculture can be seen in the current trend depicting urban farms as "farm towers"; architecturally elaborate skyscrapers with slick, futuristic stylings, jam packed with crops, dozens of stories tall[4]. Like industrial agriculture, these food towers are technologically innovative, highly controlled, mechanized systems reliant upon intensive infrastructure and energy inputs. Like Biosphere 2's $150 million replication of five natural ecosystems under hermetically sealed glass, the farm tower concept forces biological processes to take place in extreme artificiality, in a supposed social void, and does so without rigorous, holistic account of the costs. Ecological designs based on maximum control of biological processes result in extraordinary energy demand, which the farm towers aim to satisfy with renewable sources. Despite the fact that the viability of operating farm towers exclusively on clean energy is questionable, the extraordinary energy intensiveness of their sheer infrastructure makes farm towers ill-suited for meeting Richard Heinberg's objective of averting food crisis' resulting from oil and natural gas price hikes while also reversing agriculture's contribution to climate change by proactively and methodically removing fossil fuels from the food system (Heinberg et al., 2009).

[4] http://www.nytimes.com/slideshow/2008/07/15/science/0715-FARMING_9.html

Additionally, rather than advance the historically important social and ecological dimensions of urban agriculture (emphasized throughout the literature), farm towers appear to perpetuate the "go big or go home" economic model of production and consumption, emphasizing high technology, visual appeal and elite consumer culture. The intrinsic complexity of farm systems; genuinely and deeply rooted in ecology, and traditionally supported by grassroots social order, appears incongruous with many of the farm towers' glamorous designs. To the extent that architectural design veils the full picture of the nature and benefits of urban agriculture, upholds the profit-oriented values of the market economy, and perpetuates technology-driven, energy intensive farm systems to the exclusion of other modes of production, it constitutes a serious obstacle for regenerative agriculture.

STRATEGIES AND COLLABORATIONS

Strategies for developing urban agriculture have always built upon its strengths. In addition to valuable ecosystem services that replenish quality of life in the urban environment, its greatest strengths include subsistence provisioning of material wealth via informal practices of production, consumption and exchange. Urban agriculture economies are intrinsically rooted in nature and tend to foster the diverse and abundant means of creating a livelihood that characterize the informal economy[5]. Historically, projects are small scale, decentralized, multipurpose, extremely varied in form and function, engaging of diverse social groups, and capable of being productive while sustaining and even regenerating natural resources. While these characteristics are desirable from the standpoint of social and ecological sustainability, they tend to contrast with the ethos of modern business.

Strategizing the path forward for urban agriculture

5 Forage Oakland employs an alternative economy in which the community's fruit trees and shrubs are cultivated like a commons, despite being located on separate, privately owned lots. http://forageoaklandmanifesto.blogspot.com/

necessarily involves finding a solution to this discrepancy in economic character between urban agriculture and the mainstream economy. To date, urban agriculture has grown almost unnoticed in many places, despite globalizing tendencies (Girardet, 2005). Ultimately, the resiliency of workers and community members in reshaping the economic landscape through a range of alternative economic practices should be emphasized over the informal economy's subordination to global markets (Lincoln, 2003). For instance, both case studies assessed in this paper feature alternative economic practices that produce viable livelihoods because they are woven into the social fabric in their particular contexts. In tune with the historic trend, herein lies a key lesson: the foremost strategy for expanding urban agriculture is to start in the local grassroots community.

Some of the emerging opportunities and strongest potential for new projects is in cities where zoning is being favorably revised and resources including funding, personnel, open space, and raw materials are being made available to foster urban agriculture in the form of backyard gardens, community gardens, non-profits or enterprises. Opportunities are likely to grow in the public realm as governments increasingly recognize urban agriculture's positive effects on livability and quality of life, as well as its cost savings advantages. For example, the Boston Natural Areas Network (BNAN) partners community groups, public agencies, non-profit organizations and businesses in the protection and expansion of urban open spaces, particularly Urban Wilds, Greenways and Community Garden[6].

Opportunity is extremely ripe in so-called "shrinking cities" such as Detroit where the industries of the previous century have declined, bringing civic life, land use and public policy to a turning point. Urban Agriculture, which has historically helped communities to achieve a livelihood during bleak economic times, is being expanded where it already

6 http://www.bostonnatural.org/communitygardens.htm

exists and implemented anew in response to acute shifts in business-as-usual such as plant closures and layoffs. In the case of Detroit, what was once the edge is becoming the center; urban agriculture is surging in popularity as a leading strategy for revitalizing blighted urban neighborhoods and stewarding abandoned urban land. However, its spread into the mainstream has led to some tension between long-established groups practicing urban agriculture for grassroots, community development and an opportunistic entrepreneur, with a bold, profit-driven vision; what has taken the poor communities generations to build seemingly can be quickly forged at one or more orders of magnitude by another with money and political power[7]. It is a poignant example of how expanding urban agriculture in the 21st century will involve reconciling traditional issues such as quality-of-life and social justice with new, profit-oriented economic practices that enable enterprises to be successful in the market economy.

Urban farms as viable business enterprises in the modern economy will undoubtably be a signature of contemporary urban agriculture. Luckily, the challenge of developing sustainable business models is reinforced by the current surge in demand for fresh, local food. Still, policy changes at the regional, national and international levels are needed to overcome structural barriers and distorted markets in the food system (Petts, 2005). Specifically, if conventional producers no longer externalized their social and environmental costs, small-scale enterprises operating according to sustainable and ethical practices would regain comparative advantage in the market. Internalization could take on appropriate standards, incentives, subsidy, taxes and regulations in order to shift profitability in favor of sustainable practices and breath life into local food systems, including urban farms. In the mean time, consumers' growing awareness of global ecological deficits is influencing the market so that, 'eco' business - characterized by ethical production,

7 http://money.cnn.com/2009/12/29/news/economy/farming_detroit.fortune/index.htm

manufacturing and marketing practices – are more common and competitive with conventional ones. This turning of the economic tide, with the help of peak oil and the social and ecological havoc wrought by big business, constitutes a major opportunity for urban agriculture to thrive as a pioneer of the ecologically and socially commercial market.

Whether compelled to boost quality of life in cities through public service, establish a thriving market enterprise, or something in between, the most valuable resource is a critical understanding of farm systems. As this project revealed, there are many different approaches to food production and its integration with culture, economy and the environment. If following historic models, the strategy has clearly been to build upon the existing social order by reflecting the goals and objectives of the local community. If blazing a new trail for urban agriculture as sustainable enterprise, the strategy should be developed using the principles of eco-effectiveness in which production is based on "doing the right thing" and eco-efficiency, which seeks to "do more with less" (McDonough and Braungart, 2002).

Regardless of the degree to which macroeconomics evolve into an ecological economy that meets the needs of present generations while preserving and restoring natural resources for future generations to meet their needs, the ultimate urban agriculture enterprise remains socially and ecologically accountable while discovering profitable strategies.

"Greening the 21st century city will improve our health, stabilize our economy and bring us all closer together as we meet in the garden."

-Jac Smit, AICP
CPULs, Viljoen, Andre, 2005

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Appendices

DEFINITIONS AND EXPLANATIONS

System Design
arranges design elements in relationship to each other to lay the physical and organizational groundwork that enables the farm system to meet goals and objectives. System design must respond to existing physical and biological conditions as well as social and economic realities of the site.

Social and Economic Structure
refers to the farm system's economic model(s) and practices, as well as the roles of people involved and the designation of leadership and decision-making authority.

Site
Existing conditions
refers to an analytical inventory including physical or biological resources, strengths, weakness, opportunities and threats of the site. Existing conditions include rudimentary features: climate, landform, water, access and circulation, vegetation and wildlife, microclimates, buildings and infrastructure, zones of use and soil fertility. The initial step of any farm system is thorough analysis of existing conditions so that available natural resources such as light, vegetation and water, and strengths and weakness such as microclimates, access and circulation can be optimized by design.

Concept
common to landscape architecture, permaculture, and forest gardening, concept may be a unifying theme, idea, or form, physically emulated through farm system design. Concept influences farm system character as it evolves from existing conditions into a designed landscape.

Design Elements
includes the biological and abiotic ingredients whose selection and arrangement determine the physical and social structure of the farm system. Due to their elemental nature, they lay the foundation for practices, system dynamics, outcome and benefits and influence the farm system's overall stability, resilience, maintenance, productivity and beauty. Successful use of design elements can lead to mutually supportive relationships within the farm system that easily produce abundant and complimentary yields.

Site preparation
includes any alterations to the site in preparation for modes of production or installing design elements.

Infrastructure
physical structures and facilities such as paths, walls, storage spaces, irrigation channels, piles of compost, etc – that shape the farm's physical form and character while determining how it works. Infrastructure is especially important in urban agriculture for overcoming and adapting to the confines of the built environment and for creating productive areas out of vertical space.

Organisms and species
Organisms and species are chosen for their direct or indirect contribution to agricultural productivity. In nature, each organism occupies an ecological niche where it survives by way of its intrinsic characteristics and functions, including a range of needs, products, behaviors, tolerances and influences. Organisms and species comprise the social community of the farm system and are selected to perform specific functions via their ecological niche. The intrinsic, biological functions of organisms and species should be carefully combined to foster mutually beneficial relationships in which needs are met and functions are utilized automatically, thereby minimizing intervention by human hand.

Organism and species diversity is a strategy for optimizing the productive potential of a site by creating a range of niches and filling them with appropriately adapted species. Increasing diversity also impedes pests and diseases and works as an insurance policy whereby the farm system produces a yield despite the affliction of one organism or species by disease or unfavorable weather.

Structural diversity
refers to variation in natural or built vertical architecture that creates productive area through vertical space. It can occur within an individual niche or between niches of the farm system. It facilitates the complementarity of diverse organisms and species, the optimal use of space, and may lead to diverse agricultural yields.

Spacing and distribution
refers to the arrangement of elements across horizontal

space. Spacing and distribution, and structural diversity, are critical design strategies for optimally accommodating the resource needs of all the farm system's organisms and species by creating maximum complementarity and minimal competition.

Practices
Instrumental in farm system management, practices are methods of strategic change that facilitate productivity. They are also an intrinsic part of farm system design influencing effectiveness and productivity. Practices should be designed to keep yields and benefits high while keeping the frequency, difficulty and cost low.

Planting/starting and harvesting
From the ecosystem perspective, the act of planting (plants) or starting (livestock) fills an ecological niche. Conversely, harvesting reopens a niche. They are the events that mark the beginning and the end of a phase of productivity. Together, planting and harvesting delimit the spatial and temporal framework needed for the particular mode of production.

Maintenance
consists of tasks that are critical to keeping the farm system going, such as shoveling compost, feeding livestock, pruning and staking plants, opening and closing greenhouses, and double digging vegetable beds. Good design should lead to a system that runs efficiently with reasonably low maintenance, leaving time and energy for other practices, rest or celebration.

Monitoring
refers to observing the behavior and performance of design elements, changes in the farm system over time, and the presence of weeds, pests, and diseases. Careful monitoring can prevent or minimize problems through foresight and serves as method for information gathering.

System Dynamics
are the movements, changes and growth that resulting from system design. While system design is mostly static, system dynamics are always changing year-to-year, moment-to-moment. The intrinsic, complex relationships between design and dynamics offer the greatest opportunity to influence outcome and benefits.

Water and Energy
are vital natural resources needed for farm systems to function. The management of these two dynamics is determined by system design and impacts all other aspects of the farm system. Sustainable farm systems should be working towards establishing renewable sources and minimizing costs and usage in order to remain economically viable, ecologically responsible, and resilient in case of shortages of these precious resources.

Soil fertility
a complex science involving physical, chemical and biological interactions between bedrock, mineral soil particles, soil water, plants, dead soil organic matter and soil organisms. Soil fertility originates in existing site conditions and is often ameliorated during site preparation. Over the long term, it results from farm system design and practices.

Most agriculture depends heavily on imports to maintain soil fertility. Importing nutrients can have severe negative impacts including terrestrial destruction in distant ecosystems, high carbon emissions, and high-embodied energy from fossil fuels burned in the harvesting, processing, packaging and shipping of fertilizers. Ecological destruction aside, the grower remains vulnerable to any number of potential economic, social or political situations that can and do affect access.

Self-renewing fertility
characterizes a system that gathers and conserves its own nutrients needed for healthy growth and productivity. Achieving self-renewing fertility completely and absolutely in a farm system is a difficult, yet important goal that can be achieved over time. Therefore, self-renewing fertility is a fundamental aspect of sustainable farm systems, offering a way out of resource vulnerability through the ability to generate that wealth in place.

Regeneration
is the ability of a farm system to regenerate soil organic matter – a critical ingredient for soil fertility. Organic matter plays the critical role of increasing the soil's water-holding capacity while storing energy and nutrients. It serves at the catalyst for beneficial plant-microorganism relationships in which the microorganisms feed upon organic matter, decomposing it and releasing nutrients to be gathered and

conserved by plants. Without plants in the system, the nutrients will be absorbed by the soil water and flow out of the soil by leaching, erosion or solar degradation (Jacke, Volume One).

Self-renewing fertility and soil regeneration are intrinsic to healthy farm systems. They are decided indicators of regenerative agriculture and goals to be reached urgently, as described by Hellwinckle, De La Torre Ugarte and Heinberg, et al.

Erosion
a liability of any farm system in which topsoil, organic matter, and fertility are lost via runoff. Erosion undermines the farm's physical stability and productivity and can significantly contribute to the pollution of waterbodies, locally and globally.

Input:Output ratio
the quantitative relationship between inputs and outputs[1] that reflects a farm system's efficiency, effectiveness and overall viability. Input:Output ratio is often disadvantageous at first because starting a new project often requires greater inputs while initial productivity is low. Once the design elements and practices have been established, the ratio becomes more accurate and serves as an essential indicator of the farm system's efficiency and productive potential.

Labor
refers to paid, unpaid and volunteer labor.

Raw materials
includes seeds, soil amendments, fertilizers, construction materials, compost, mulch, etc.

Productivity
the output achieved by a mode of production within a given area.

Pollution
any solid, liquid or airborne contamination exceeding

1 "Costs and Benefits of Urban Agriculture", by Rachel Nugent, provided many of the input and output metrics for the framework.

the farm system's ability to reabsorb and recycle it in a sustainable way, thereby affecting land use and air, soil or water quality nearby or far away.

Waste
unrecyclable or noncompostable byproducts requiring disposal outside of the farm system, for example, landfill.

Outcome and benefits
refers to the broad culmination of effects resulting from the design and dynamics of a farm system. Outcome and benefits may encompass original goals articulated in advance, as well as unexpected outcomes – positive or negative.

Gross Agricultural Yield
a function of productivity and the amount of area cultivated. Gross agricultural yield indicates the total yield of an individual system or productive mode within a system.

Marketed and nonmarketed goods
Gross yields are translated into marketed and non-marketed goods, which are indicated by their weight, volume, % of crop, or market price as applicable. Marketed goods can be measured formally in terms of annual gross, and nonmarketed goods can be measured in terms of the weight, volume, and percent of crop that is utilized for subsistence or informal economy.

Ecological Benefits
Waste recycling
refers to the recycling of landfill-bound materials generated within the farm system or the greater urban ecosystem. The ability to recycle its own waste is an important indicator of sustainable farm systems, while the ability to absorb the wastes from other parts of the city is a major ecosystem service. Waste recycling diverts waste from the urban waste stream, regenerates organic matter needed for soil fertility, and creates substantial cost savings opportunities; a single activity producing compound benefits.

Reduced food miles
refers to a decline in the distance traveled by food items and/or the amount of food traveling long distances. Reduced food miles translates into reduced usage of fossil

fuels and transportation infrastructure, and helps to correct the ratio between calories spent to grow and ship food and actual calories within the food [2]; a shift that favors growers, consumers and the environment. Fresher, more nutritious produce is another advantage of reduced food miles.

Biodiversity
refers to the variety of plant and animal species and the size of populations supported by the farm system. Urban agriculture fosters wildlife by offering valuable habitat in the city. Depending on its size and the nature of the design and dynamics, the farm system can serve as a stepping-stone for habitat connectivity facilitating the movement of wildlife [3]. Biodiversity also includes the variety of the farm's cultivated organisms and species for which the site serves as primary habitat. In either case, urban farms create the opportunity for humans, domesticated and wild species to interact, share space and natural resources within the urban environment.

Air, soil, and water quality
refers to that of the immediate urban environment as well as the region, nation, and globe –whatever extent is being affected, either positively or adversely by the goings-on of the urban farm system.

Economic Benefits

Enterprise development
refers to the ability to establish and expand farm- based business within the formal or informal economy.

Household savings
refers to food production that results in significant savings in household food budgets.

Job creation
refers to taking on laborers in response to a need for additional help in maintaining the farm system[4].

Investment opportunities
are financial surpluses that augment the incomes of families and enterprises and may in turn be used to initiate new investment opportunities[5]. Investment opportunities and

[2] Heinberg, et al., 2009
[3] Dramstad, et al.
[4] Smit, 1996
[5] Petts, 2005

enterprise development are important indicators of farm system viability.

Diverse economy
refers to informal, non-market based transactions or exchange that foster the diverse and abundant means of creating a livelihood. Examples of diverse economy include bartering, volunteering, mutual aid, home-based production and subsistence. The diverse economy has the potential to be two or more times the size of the formal economy, but is often completely unaccounted for by standard economic indicators. Therefore, indicating, mapping and measuring the diverse economy is an important part of verifying and completing the knowledge on the economics of urban agriculture.

Social Benefits

Dietary diversity
refers to the range of food groups (eg. fruits, vegetables, meat, grain, dairy) and the variety within those groups augmented by the urban farm system. Dietary diversity encompasses the importance of fresh, nutrient-dense foods in preventing food-related illnesses such as diabetes; a major food security/social justice issue ameliorated by urban agriculture.

Education
refers to sharing and disseminating a body of knowledge associated with urban food production practices and related subjects. The work involved in managing and maintaining farm systems creates educational opportunities, which provide purposeful and productive social activities. As farm systems are physically and figuratively rooted in a place, they can serve as a platform for social interaction around the common cause of learning.

Quality of life
refers to the ability to meet basic needs of food, shelter, employment, education, and health care, as well as community membership.

Food security
refers to access and availability of sufficient quality and quantity of food for all individuals, regardless of climate, harvest, social level or income [6].

[6] World Health Organization (WHO) Europe, 2000

COMPREHENSIVE CASE STUDY ANALYSIS SURVEY [7]

Social/Economic model

Who:
What: Non-profit, public sector, conventional or alternative market-based enterprise, individual, conglomerate of partnerships:
Use: How is it used? Who uses it? Who doesn't use it?
Roles of key participants: Nature of teams: Leaders:
Social structure:
Theoretical underpinning:
Goals: Definition of target problem:
Program elements:
Program development:
Decision-making and implementation process:
Production, appropriation and distribution of wealth:
Transactions, calculations and commensurability:
Need-based economy: barter/trade, mutual aid, subsistence:
Distribution and remuneration of labor:
Operating budget:

System Design

Site
Existing conditions

Location:
Size:
Land use and density:
Climate:
Landform:
Water:
Access and circulation:
Vegetation and wildlife:
Microclimates:
Buildings and infrastructure:
Zones of use:
Soil fertility: nutrient levels: contamination:

[2] Derived in part from Francis, 1999

Design Elements
Concept
What are the key design concepts?
What is the inspiration for form?
How are goals translated into form?

Site Preparation
What interventions took place?
How does it respond to site conditions?
Low, medium, high intensity?

Infrastructure
Physical and organizational structures and facilities:
Low, medium, high intensity?

Organisms and species
Organism and species:
Low, medium, high diversity?

Spacing and distribution
Spacing and distribution:

Structural diversity
Varied architecture above and below ground, guild and polyculture design:
Low, medium, high diversity?

Practices
Planting and harvest
Planting methods:
Harvesting methods:

Management
Planning and guiding change, encouraging desired species, and discouraging undesired species: fertilization, pesticide use:

Maintenance
Grunt work:

Monitoring
Mapping and observing element performance and behavior, soil development, weeds, pests, and diseases:

System Dynamics
Water
Low, medium, high usage:
Source:

Soil fertility
Self-renewing fertility: Y/N
Erosion: Y/N
Regeneration: Y/N
Energy demand
Fossil fuels: Y/N, low-high usage
Renewable fuels: Y/N, low-high usage

Plant health
Survival rate: % crop
Pest damage: Y/N, % crop affected

Input:Output ratio
Inputs
- Raw materials: low-high cost
- Land: low-high cost
- Tools and machinery: low-high cost
- Labor:
  - Paid: low-high cost
  - Unpaid: low-high cost

Outputs
- Pollution: Y/N, low-high
- Waste: Y/N, low-high

Outcome and Benefits
Typology
Typology diagnosis:

Agricultural productivity
AP= cultivated area x output per area:
Marketed goods: Annual gross
Nonmarketed goods: informal economy, subsistence

Ecological Benefits

Waste recycling: Y/N, amount annually
Reduced food miles: Y/N
Air, soil, water quality: increase/decrease
Biodiversity: increase/decrease

Social Benefits
Dietary diversity: Y/N
Quality of life: How is the community served by this project? What does it look and feel like? How perceived and valued? Affect on ability to meet basic needs?

Education: Interns, volunteers, students
Food security: access, availability, affordability of healthy food

Economic Benefits
Enterprise development: Y/N
Investment opportunities: Y/N
Household savings: Y/N, %
Job creation: formally/informally employed
Diverse economy: trade, barter, mutual aid, exchange of skills and services

Peer reviews
Criticism
Awards or special recognition
Significance and uniqueness of project
Limitations
Generalizable features and lessons
Future issues and plans
References and contacts
Keywords

System Design

▪ = low ■ = medium ■ = high

VALUE METRICS

	Practices				Design Elements					Site	
	monitoring	maintenance	harvesting	planting/starting	spacing & distribution	organisms & species	structural diversity	infrastructure	site preparation	concept	existing conditions
description											
intensity											
diversity											
Turns problems into solutions											
Observes, interacts, responds											
Values & integrates diversity											
Produces abundant, complimentary yeilds											
Renews water, energy, fertility & inputs											
Regenerates organic matter & topsoil											
Captures waste from the urban waste stream											
Produces no pollution or waste											
Reduces food miles											
Fosters neighborhood safety & community cohesion											
Fosters access to food, education & employment											
Fosters formal or informal economy											

DATA ASSESSMENT CRITERIA

System Dynamics

■ = low ■ = medium ■ = high □ = zero

Y = yes **N** = no

DATA | ASSESSMENT CRITERIA

VALUE METRICS

			description	yes/ no	usage	cost	output	percent of crop	Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
Water	source																			
Energy	fossil fuel																			
	renewable fuel																			
Soil fertility	self-renewing fertility																			
	erosion																			
	regeneration																			
Plant health	survival rate																			
	pest damage																			
Input:Output ratio	raw materials																			
	land																			
	tools & machinery																			
	labor																			
	productivity																			
	pollution																			
	waste																			

Outcome & Benefits

■ = low ■ = medium ■ = high

⬆ = increase ⬇ = decrease

Y = yes **N** = no

	VALUE METRICS	DATA					ASSESSMENTCRITERIA											
		description	yes/no	increase/decrease	annual total	annual cost savings	Turns problems into solutions	Observes, interacts, responds	Values & integrates diversity	Produces abundant, complimentary yeilds	Renews water, energy, fertility & inputs	Regenerates organic matter & topsoil	Captures waste from the urban waste stream	Produces no pollution or waste	Reduces food miles	Fosters neighborhood safety & community cohesion	Fosters access to food, education & employment	Fosters formal or informal economy
	typology																	
Economic benfits	enterprise development																	
	investment opportunities																	
	household savings																	
	job creation																	
	diverse economy																	
Ecological benefits	waster recycling																	
	reduced food miles																	
	air, soil, water quality																	
	biodiversity																	
Social benefits	dietary diversity																	
	education																	
	quality of life																	
	food security																	
Gross yield	marketed																	
	nonmarketed																	

Investment Principles	Permaculture Principles
Use "Total Economic Return"	Obtain a Yield Produce NO WASTE The Problem is the Solution Stacking Functions
Quadrants: Liquid vs. Nonliquid and Local vs. Global	Catch and Store Energy Use and Value Renewable Resources and Services Designing From Pattern to Detail Site Analysis - Zones
Scenario Planning "plan for the worst and hope for the best"	Observe and Interact Creatively Use and Respond to Change Designing From Pattern to Detail Site Analysis
Diversify "don't put all your eggs in one basket"	Use and Value Diversity Use Edges and Value the Marginal
Financial Intimacy "build networks of trust"	Apply Self Regulation and Accept Feedback Designing From Pattern to Detail Site Analysis - Zones
Organize/ Conspiracy "Take control of your power"	Zones - Relative Location (Companion Planting, Guilds) Stacking Functions (one group achieving complimentary functional yields and producing net energy plus)
Play Net Energy Plus "Pay it forward"	Apply Self Regulation and Accept Feedback Integrate Rather than Segregate Catch and Store Energy Obtain a Yield Produce no Waste

* Investment principles taken from Solari Inc. with permission from Catherine Austin Fitts. For access to Solari finance principles view http://solari.com/store/audio-seminars/positioning_your_assets/

Figure 7 - 1 Comparison of investment and permaculture principles
Source: Jennifer Dauksha-English, 2008

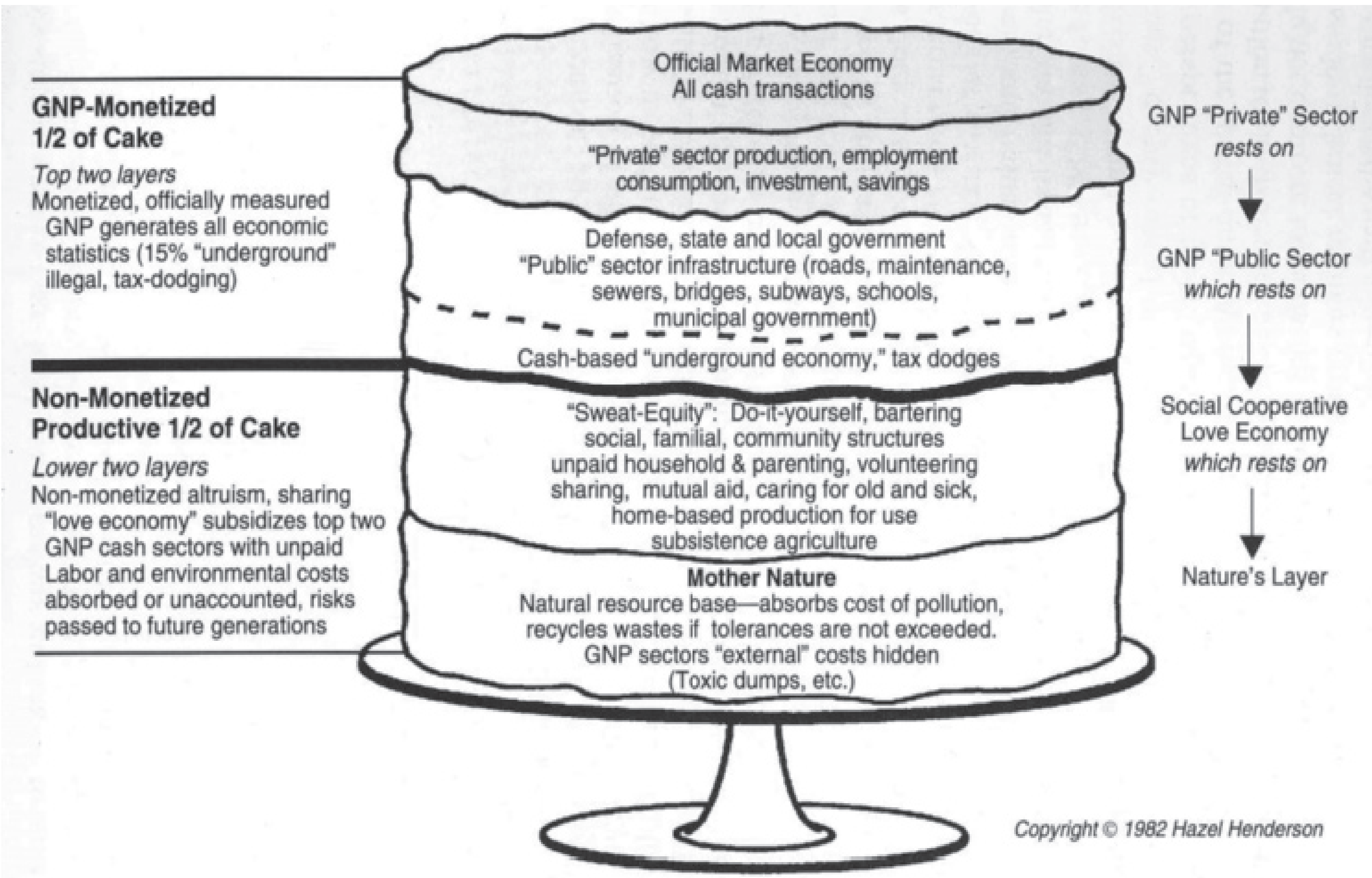

Figure 7 - 2 Total Productive System of an Industrial Society (Layer Cake with Icing)
Source: Hazel Henderson, 1996

ECONOMY	*COMMUNITY* ECONOMY
a-spatial/global	place-attached
specialized	diversified
singular	multiple
large scale	small scale
competitive	cooperative
centered	decentered
a-cultural	culturally distinctive
socially disembedded	socially embedded
nonlocal ownership	local ownership
agglomerative	dispersed
integrated	autonomous
export-oriented	oriented to local market
privileges short-term return	values long-term investment
growth oriented	vitality oriented
outflow of extracted value	recirculates value locally
privately owned	community owned
management led	community led
controlled by private board	community controlled
private appropriation and distribution of surplus	communal appropriation and distribution of surplus
environmentally unsustainable	environmentally sustainable
fragmented	whole
amoral	ethical
crisis-ridden	harmonious
participates in a spatial division of labor	locally self-reliant
MAINSTREAM ECONOMY	*ALTERNATIVE* ECONOMY

FIGURE 23. Key words of economy and community economy. From Bernard and Young (1997), Crouch and Marquand (1995), Meeker-Lowry (1995), Ife (1995), Pearce (1993), Power (1996), and Wildman (1993).

Figure 7 - 3 Key words of economy and community economy.
Source: J.K. Gibson-Graham, 2006, pg. 87